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**THE RELATION OF INCISIONAL AND
INGUINAL HERNIAE AS WELL AS OF
MECHANICAL INTESTINAL DISTURBANCES
TO PREVIOUS OPERATIONS
FOR APPENDICITIS WITH
PERITONITIS**

BY

AUNE PITKÄNEN

HELSINKI 1948



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AFTER-EXAMINATIONS FROM THE VIIPURI COUNTY HOSPITAL
(CHIEFS: PROF. PEDER GRANBERG † AND LENNART PETERSON M.D. †),
THE I AND II SURGICAL CLINIC OF THE UNIVERSITY OF HELSINKI
(CHIEFS: PROF. ALI KROGIUS † AND PROF. TAUNO KALIMA) AND FROM
THE MARIA CITY HOSPITAL (CHIEFS: PROF. RICHARD SIEVERS †,
PROF. JARL HAGELSTAM † AND PROF. HENRY BARDY †).

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MERCATORIN KIRJAPAINO

*DEDICATED TO THE FORMER
VIIPURI COUNTY HOSPITAL*

PREFACE.

The chief of the Viipuri County Hospital, LENNART PETERSON, M.D., was at one time, greatly interested in the question of the extent to which late complications followed different incisions employed in surgical treatment of appendicitis with peritonitis. He could not investigate this problem himself on account of an overwhelming burden of work, but entrusted me with the task. My statistics based on after-inquiries were completed as early as in 1939 but at that time my work was interrupted for nearly six years by the war and the demands that it made on me. In 1945 I could at last begin the final treatment of my work. It was often impossible to obtain original sources of reference, the literature of the University particularly older works, being still packed in cases and stored away in cellars.

It is my pleasant duty to express my deep gratitude towards the late Dr. PETERSON for the valuable advices and encouraging support I received from him during my investigations. He was honoured for his personality and his prominence as surgeon particularly by the South-Carelian population; but above all he was a teacher who worked with unsparing ardour for the young generation of doctors.

I am also much indebted to Prof. TAUNO KALIMA and to the late Prof. HENRY BARDY who have kindly placed the records of their hospitals at my disposal.

Further I am deeply grateful to Prof. A. J. PALMÉN who after the death of Dr. PETERSON, has willingly directed my work and given me much valuable advice.

In this connection I also wish to thank all doctors and nurses of the former Viipuri County Hospital who in some way or other have assisted me in my work.

My thanks are due also to O. KETONEN D.Phil. for revising the statistics of my investigation and for valuable advice.

I thank Mrs. GUNVOR HUSTICH for translating my manuscript into English, and Miss ELLEN EAGER and Dr. HELMI LEPPÖ for their aid in reading through the translation.

Helsinki, 1947.

AUNE PITKÄNEN.

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INTRODUCTION.

The appendix has been subject to particularly great interest and scientific investigation during the last century. The literature on the appendix, on morbid conditions caused by it and on the treatment of such conditions is extremely abundant. Thus scientists of the last decades have established that one lifetime is not enough for careful investigation of the literature, as about 10 investigations on this theme still appear weekly, which has been mentioned by BAUER in his large monograph of 1933. There is hardly any subject which has not been dealt with and in the treatment of which reiteration could be avoided.

According to literature a pathologically changed appendix was first mentioned in 1711 when HEISTER at autopsy observed a dark appendix firmly attached to the parietal peritoneum. When freed, it ruptured and contained several teaspoonfuls of pus. In 1759 MESTIVIER gave account of a perforated appendix in a patient.

Not until the beginning of the last century, however, was the research of the appendix and of morbid conditions caused by it properly commenced. PARKINSON (1812) and WEGELER (1813) reported on a death caused by concretion and severe changes in the appendical wall. LOYER-VILLERMAY (1824) and MELIER (1827) described an inflammation of the peritoneum brought on by a rupture of the appendix. MELIER pointed out that in case inflammation of the appendix is established, the disease should be operatively treated. However, the treatment remained stubbornly conservative until 1886 when the Boston surgeon REGINALD FITZ first put operative treatment of the appendix into practice. He also suggested and put to use the international denomination »appendicitis» for inflammation of the appendix (1888).

The great improvement in the treatment of appendicitis and of peritonitis following it, is a well known and commonly admitted fact in medical quarters, although there are still, particularly in America, supporters of the conservative line. However, the operative method successfully applied in the curing of the original disease, may sometimes cause complications of a more serious character than the disease. There are many such possibilities. Both early and late complications occur.

The most important late complications are the incisional herniae of the abdominal wall which may be causally connected with the method of operation, the structure of the abdominal wall and local infections, or adhesions of different parts of the peritoneum, which may give rise to various mechanical intestinal disturbances. It is quite evident that efforts should be made to develop a technique in which later complications in connection with the scar are, as far as possible, avoided.

I.

RELATION OF INCISIONAL HERNIAE TO A PREVIOUS OPERATION FOR APPENDICITIS WITH PERITONITIS.

General Part.

General Demands on Abdominal Incisions.

When operative treatment was commonly accepted in appendicitis, an abundance of scientific papers appeared in which every possible problem in connection with the operation was dealt with. The leading surgeons tried multifarious methods in order to obtain as good results as possible. Intra-abdominal measures as also abdominal incisions varied greatly in different hospitals. A method of operation praised as remarkable by one authority was rejected by another. Everyone published statistics for the support of his own opinion. Now, when the aseptic laparotomy technique has already passed the first fifty years, there is still great disunity even with regard to the question of the abdominal incision. One considers one thing, the other another as the most important in a laparotomy incision, and so greatly varying methods for the opening of the abdominal cavity are decided upon. In the course of the years a certain unanimity in the question of the incision has, however, been attained. This is the case, for instance, with regard to the demands which a satisfactory abdominal and particularly an appendectomy incision must fulfil.

According to literature the aforesaid demands are, on the whole, the following:

1) The form of the abdominal incision must be adapted to the purpose and the course of the operation, and must allow satisfactory exposure of the abdominal cavity.

2) The abdominal incision may as little as possible injure the tissues. Therefore, nerves of the abdominal wall, bloodvessels, muscles and their fasciae as well as aponeuroses should be spared.

3) If necessary it must be possible to enlarge the incision without even cutting across any fibrous tissue.

4) It must be possible at the end of the operation to unite the edges of the wound so that the ensuing scar should cause no functional disturbances of the abdominal wall.

5) Should the wound heal per secundam, it must be possible to re-establish normal conditions by means of an after-operation even when suppuration has delayed the healing of the tissue.

These rules are simple and clear, but they are often difficult to follow owing to the anatomy of the abdominal wall (LEHMANN 1941).

The incision may injure the tissue as little as possible. The injuries are, according to DRÜNER (1921), in direct proportion to the size of the tissue incision. KOCHER wrote as early as in 1902: »Den wahren Chirurgen erkennt man daran, dass er die Haut in ergiebiger Ausdehnung spaltet, aber in der Tiefe der Wunde möglichst sorgfältig und schonend vorgeht.»

Classification of the Appendectomy Incisions and their History.

During the period of surgical treatment of appendicitis a vast number of different incisions occurred according to what at the time was considered the most important feature of the incision.

Among these numerous incisions there are some which closely resemble one another and which may be divided into groups on the basis of their situation, the method of procedure and their character, for instance, as follows:

1. Oblique incisions in one plane:

The incision follows the course of the inguinal ligament

being mostly carried down through all layers in the same ventro-dorsal plane.

2. Gridiron and »button-hole» incisions.

The different abdominal layers are divided parallel to their fibers. — The button-hole incisions do not actually form a group of their own, but differ from the ordinary incisions only in the fact that an incision as small as possible, mostly resembling a gridiron incision, is made.

3. Transverse incisions.

An incision in one plane of all abdominal layers in a transverse direction in relation to the long axis of the body.

4. Longitudinal incisions.

An incision parallel with the long axis of the body, either in the middle line, or on either side nearer or farther from it.

1) Median longitudinal incisions.

2) Paramedian » »

3) Pararectus » »

5) Lumbar incisions.

An incision in the lumbar region divides the different tissue layers parallel with their fibers, or all layers in the same plane.

These incisions, the median incision excepted, have been developed in the course of half a century. There are numerous modifications of the various incisions of each group, many of which have been used for a certain period, and rejected in favour of better procedures. Many incisions, however, have stood the sharp criticism of many decades. SPRENGEL (1906) mentions that a determining factor for the character and situation of the appendectomy incisions has been the question of the purpose of the operation. If the purpose was, for instance, only to empty a limited abscess, a lateral oblique incision was performed, whereas in diffuse peritonitis a median incision and for the radical removal of an inflamed appendix a pararectus incision is made.

The development of the appendectomy incisions and their nature will be best described by the surgeons themselves relating why they have used a certain incision, or a modification of it, and what merits and disadvantages they have experienced. I shall, in the

following, give a historical survey of surgeons representing different groups of incision and of their opinions. It must be observed, however, that the difference between many incisions of different groups is very vague, to an extent allowing some incisions to be referred to several different groups.

1. *Oblique incisions in one plane.*

ROUX in 1890 recommended an incision following the course of the inguinal ligament, about 2 cm above it and about 15—18 cm long. The center of the incision was at the level of the spina ilica ventralis.

SONNENBURG used an oblique incision similar to that of ROUX but still nearer to the inguinal ligament in order to avoid incisional herniae, in favourable cases carrying it down bluntly in the direction of the fibers through the deeper muscular layers. When making the incision SONNENBURG retracted the skin in a medial direction in order that the postoperative scar of the skin and not of the deeper layers be in the same ventrodorsal plane.

AMBERGER (1906) recommended an oblique incision in cases where a long incision is required. For the same reason also LENNANDER (1906) recommended it, particularly in peritonitis following appendicitis, when it should be made between the XI and XII intercostal nerves, or between the XII intercostal and I lumbar nerve. In drained cases he advised the incision to be enlarged in a medial direction, its lower end reaching behind the rectus muscle which was displaced medially. When the drainage is not too prolonged the withdrawing rectus muscle, after the removal of the drain, prevents the formation of an incisional hernia in the drainage opening. AMBERGER, on the other hand, did not consider this a great advantage as there is, anyhow, an opening in the aponeurosis which will be permanent in case of a prolonged drainage, neither will the muscle withdraw completely in such a case.

In an incision following the course of the inguinal ligament, the number of incisional herniae is influenced by the fact that this incision is generally made long which results in motor nerves being injured. Later LENNANDER absolutely rejected the use of oblique incisions in one plane.

This incision corresponds, in fact, to the general position of the appendix, allowing a good intra-abdominal exposure but the fibers of the internal oblique and transversalis must be cut which easily forms a base for incisional herniae as the muscle ends draw apart and the suture may fail. In drained cases the peritoneum thus exposed may prolapse through the muscular opening, and herniation is certain.

2. *Muscle-splitting incisions.*

The muscle-splitting incision was first introduced by the American surgeon MCBURNEY (1894, «Gridiron incision»). He made an incision of about 10 cm obliquely above the inguinal ligament and perpendicular to a right line from the spina ilica ventralis to the umbilicus, about 2.5 cm from the spina medially. One third of the incision was performed above the said right line in the muscular region of the external oblique, two thirds in the aponeurosis. The aponeurosis of the external oblique was split parallel with its fibers as also the internal oblique and the transversalis bluntly at the level of the spina ilica ventralis whereafter the transversalis fascia and peritoneum were incised in the same direction.

Modifications of the muscle-splitting incision and their supporters.

WEIR in 1900 also made the skin incision according to MCBURNEY. He then divided the aponeurosis of the external oblique and the fascia of the rectus muscle transversely to the long axis of the body and to the linea alba. The rectus muscle was then retracted medially, dividing the transversalis fascia and the peritoneum also crosswise. This incision permits an extremely good intra-abdominal exposure. WEIR's incision may also be referred to the transverse incisions.

RIEDEL (1905, «Zick-Zack-Schnitt») made an oblique skin incision 1—1.5 cm above the inguinal ligament dividing the aponeurosis of the external oblique parallel with its fibers and then the internal oblique parallel to its fibers about 1 cm above the inguinal ligament, and enlarging the incision in the same direction — thus laterally to the right and upwards medially — to the rectus sheath, the anterior sheath of which was opened 2 cm transversely. The fibers of the transversalis were incised as far as to the rectus sheath,

likewise the transversalis fascia and peritoneum in the same direction. He opened the peritoneum first in the direction of the inguinal ligament and then in the direction of the rectus sheath continuing the incision sometimes as far as 1—2 cm under the rectus muscle.

SPRENGEL (1910) recommends the exclusive use of MCBURNEY's gridiron incision. He states that he used two different methods of enlarging the gridiron incision in cases when the appendix was situated above, below, or medially of its normal place. Having incised the skin and the external oblique in the direction of the fibers, he divided the deep abdominal muscles, the transversalis fascia and the peritoneum through one longitudinal incision upward or downward. Thus he obtained ample exposure but the cut muscles often retract in spite of muscular sutures, resulting in incisional herniation. Therefore, he advised already in 1910 that this method of enlargement should be abandoned, suggesting that the gridiron incisions be enlarged as follows: The incision in the internal oblique and the transversalis is prolonged in the course of the fibers of the internal oblique, and the right rectus sheath is also divided as far as necessary. The rectus muscle and the nerves running posterior to it are retracted medially, the transversalis fascia and the peritoneum being divided transversely. — Should the exposure thus obtained not be satisfactory, he further divided, totally or partially, the rectus muscle. Closure of this kind of wound is easy as there is no tension and drainage is easily applied to its lateral portion. Before long he abandoned also this method. In 1914 SPRENGEL recommends the sole use of the gridiron incision, bluntly enlarged when necessary. Only seldom extension of the wound through incision of the deep muscles in the area of their aponeuroses towards the rectus sheath in the course of the fibers is necessary.

A successful use of this German »erweiterter Wechselschnitt» according to SPRENGEL, is reported by the Chicago surgeon CLAGETT (1927).

WOLKOWITSCH in 1898 described an incision closely resembling RIEDEL's zig-zag incision only situated higher up. The deep abdominal muscles were split starting from the spina ilica ventralis or from the crista ilica in the course of their fibers. He divided regularly the ventral sheath of the rectus sheath, and in case he still did not obtain proper exposure, he made an additional cut upward or

downward from the medial end of the original incision adapted in each case to the abnormal location of the appendix. WOLKOWITSCH claims to have introduced this method himself, and only later to have made acquaintance with MCBURNEY's and LENNANDER's incisions through literature.

JATROU (1920) recommends the use of the muscle-splitting incision and, should greater exposure prove necessary, to extend it through division of the aponeurosis of the external oblique to the rectus sheath, then making an auxiliary incision according to LENNANDER.

CHASTENET DE GERY (1922) used a muscle-splitting incision largely resembling RIEDEL's and WOLKOWITSCH' incisions. The skin incision is extensive, setting out from the center of the umbilico-iliac line in the course of the fibers of the external oblique. At the medial end of this incision the deep abdominal muscles are split parallel to their fibers and the rectus sheath is divided. The muscle is retracted medially, the transversalis fascia and peritoneum are cut transversely, the epigastric vessels having been ligated.

PHOCAS (1927) supported the use of the gridiron incision, but the skin and subcutis had to be divided through an incision in a direction from the spina ilica ventralis to the umbilicus. This incision allows ample retraction being transverse to LANGER's lines.

BAGGIO (1932) recommends in cases where the appendix is abnormally located, for instance caudally from its normal place, the changing of MCBURNEY's incision into a so-called »Lappenschnitt», an outwardly curved incision through the skin, aponeurosis and the external oblique, the abdomen being opened in a direction from the spina ilica ventralis to the junction of the internal oblique and the rectus sheath. If a larger field of vision is still needed, extension according to LENNANDER should be performed.

FISKE & RHAME (1934) expressed their opinion on all incisions so far described, considering them either too small and allowing insufficient exposure, or too large and resulting in incisional herniation. They recommended an incision of the MCBURNEY type in the course of the muscle fibers, the skin incision being made obliquely from the lateral one third of the rectus muscle 2 cm above the spina ilica ventralis from where it still continued some distance in the direction of and 1 cm above the crista ilica.

The ilio-inguinal nerve was retracted laterally. If the incision had to be extended, extension was performed by dividing the rectus sheath and retracting the rectus muscle medially, or by splitting the peritoneum laterally as far as to its turning point (bis zur Umschlagsstelle). The appendix was easily located in this way.

BOGOJAWLENSKY (1901) advised the use of MCBURNEY's incision in appendicitis because it saves motor nerves as well as muscular and tendinous layers. Also v. BARACZ (1907) who made a journey to America in 1902, there acquainting himself with MCBURNEY's incision, supported it as an excellent operative incision. The drawback of the gridiron incision, viz. that it does not afford sufficient exposure of the abdominal cavity, was considered by WOLFSON & MORSE (1926) as an advantage preventing the surgeon from unnecessary exploring in the abdominal cavity. The interference of the surgeon being limited to the focus of the morbid process, contamination of the free clean abdominal cavity was avoided. Thus WOLFSON recommended the use of MCBURNEY's incision particularly in cases of perforated appendix, gangrene, abscess or appendicitis with peritonitis. He also considered it an advantage that this incision is easy to perform, to close and to enlarge and that post-operative herniation is rare.

FÖRSTER who in 1928 published statistics on 1 053 cases of appendectomy, arrived at the conclusion that the result of the external exploration should determine the character of the incision. He used, however, in most of his cases MCBURNEY's incision, as did also ORBACH (1934), GUADAGNINI (1935), GOÑI MORENO (1938), BANCROFT (1939), SZABO (1939) and NASSAU & LORRY & PULASKI (1941).

»Buttonhole» incisions.

As I already mentioned (p.) the buttonhole incision cannot be considered a method, the size of an incision not being regarded as a base for a method, as was already stated by v. HABERER (1905), SPRENGEL and v. EISELSBERG (1906).

»Buttonhole» incisions have met with much opposition. Thus, in the opinion of among others v. HABERER and SPRENGEL a very small incision does not suit any stage of acute appendicitis, but the use of it results in many a disadvantage: a poor view of the abdo-

minal cavity, retraction of the tissues, in acute cases a greater risk of perforation etc.

The reasons which have induced a number of surgeons to use as small appendectomy incisions as possible, and the actual size of these incisions, appears from the following:

HAHN (1905) made a skin incision halfway between the spina and the linea alba medially somewhat obliquely laterally downwards medially. The length of the incision was maximum 3—4 cm, in fat persons 6—7 cm. The rectus sheath was opened in the direction of its border avoiding vessels and nerves. The incision was so small as to hardly allow the introduction of his forefinger. HAHN affirmed it better to identify the appendix by the hand than with the aid of his eyes through a large wound, and that it did not matter whether it was a question of a slight appendicitis or peritoneal abscesses and adhesions.

ROBINEAU (1913) also recommended as small incisions as possible as in these eventration does not occur, healing is rapid and the cosmetic result satisfactory, the scar vanishing completely in 2 to 3 months. ROBINEAU used an incision of 17—18 mm of the gridiron type.

POENARU-CAPLESCU (1923) states that he operated 800 cases of appendicitis through an incision the maximum length of which was 4 cm. The smallest incision used by him was 7 mm long. Post-operative adhesions and other complications were, in his opinion, rare when this method was applied.

SCHIPPOREIT (1937) used, during the years 1928—1937, in 1886 appendectomies an incision the length of which varied between 1 and 3 cm. The patients recovered well according to his own report, incisional hernia occurring in one case only. SCHIPPOREIT stresses, however, that the diagnosis must be certain when a small incision is chosen.

NOETZEL (1937) stresses the importance of a cosmetic scar stating that he used as small as possible a MCBURNEY incision particularly in women. The skin incision was made into the skin furrow which sets out from the spina ilica ventralis continuing downwards medially, if such a furrow existed in the patient.

KULENKAMPFF (1938) made a small transverse incision of 2—3 cm at the level of the spina from the border of the rectus sheath

outwards. He also divided the aponeurosis of the external oblique in the same direction, the deep abdominal muscles, however, parallel to their fibers. Incisional herniation rarely occurred and, according to KULENKAMPFF, the scar was cosmetically satisfactory.

BIER (1906) and MONTEIRO (1941) also recommend »buttonhole» incisions, the latter particularly stressing the advantage of a small incision with regard to the cosmetic result and the rare occurrence of incisional herniae. The American surgeons ROMANIS & MITCHNER (1944), on the other hand, state that appendectomy performed through a small incision is »a mark of total lack of surgical balance».

3. *Transverse incisions.*

Transverse incisions have been used among others by KRAJEWSKI and his pupil WERTHEIM. The incision preferred by them is actually a modification of WEIR's muscle-splitting incision.

According to A. WERTHEIM (1907), KRAJEWSKI used transverse incision in appendectomies, particularly in the quiescent stage. The skin incision is made at the level of the spina ilica ventralis transversely perpendicularly to and almost reaching as far as to the linea alba. The aponeurosis of the external oblique and the anterior sheath of the rectus muscle are cut across whereafter the internal oblique and the transversalis are divided bluntly parallel to their fibers. The rectus muscle is displaced medially, and the transversalis fascia and peritoneum are also split transversely (2—3 cm). According to WERTHEIM KRAJEWSKI's incision was never followed by incisional herniae after primary closure of the wound, nor even in cases when the healing of the wound was disturbed by suppurating sutures.

According to GERTKEMPER (1928) transverse incisions in appendectomy were used also by CHAPUT, LANZ, WINKELMANN, LEXER, SICK and others.

Modifications of transverse incisions and their supporters.

DAVIS (1906) and VERHOOGEN (1913) report a successful use in appendectomy of a small transverse incision at the level of the spina ilica ventralis.

FLOECKINGER (1914) recommends a transverse incision to the

area of the rectus sheath in order to obtain, particularly in cases of chronic appendicitis with adhesions, a good general view. According to FLOECKINGER the danger of incisional herniation in connection with this incision is small because the incision is parallel to the fibers of the muscular aponeuroses and consequently to the muscle tension, and because the rectus muscle separates the peritoneal and the superficial wound, preventing the intra-abdominal pressure from tearing the sutures.

A combined transverse-longitudinal incision was recommended by JAYLE (1920). The skin and aponeurosis was transversely incised above the pubic eminence, the rectus sheath next being divided longitudinally near its border according to LENNANDER. A good view of the appendix and the pelvic viscera was thus obtained. A good scar was also secured.

IESU (1940) preferred quite the same kind of transverse-longitudinal incision as did JAYLE starting the incision, however, above the pubis, 2—3 fingers' breadth from the pubic bone, extending the skin incision when necessary as far as to the linea alba or the spina ilica ventralis.

ROCKEY (1924) suggests particularly in cases of suppurating, retrocecal and lateral appendicitis a transverse incision the center of which lies in McBURNEY's point, the lateral end above the spina ilica ventralis and the medial end on the rectus muscle. All aponeuroses are divided by one incision, the rectus sheath only at the border. The wound is retracted upwards and downwards when the fibers of the flat abdominal muscles give way and split to a certain extent affording a larger operative field.

HINTERSTOISSER (1926) and SCOLLO (1932) recommend a transverse incision in the direction of LANGER's skin lines. They also open the rectus sheath transversely leaving, in case of an abscess, the wound outside the rectus sheath open.

COKKINIS (1931) considers the best incision to be a transverse incision which he makes at a distance of 3—5 cm from the spina ilica ventralis exactly according to the KRAJEWSKI method described by WERTHEIM, paying particular attention to the ilio-inguinal nerve. In his opinion the appendix is easily found by the hand through this incision. Should it be located deep in the true pelvis its removal may prove difficult.

MELANDER (1931) arrives at quite the reverse opinion recommending a similar incision particularly in appendectomy in women. According to him the advantage of the incision is that it allows a good general view also of the viscera of the true pelvis as there are frequently changes in the uterus and adnexa in connection with appendicitis in women (MELANDER reports changes in the pelvic viscera in 14 (25 per cent) out of 56 operated cases of appendicitis).

Transverse incisions have further been used and recommended by the Russian GUSYNIN (1933) and the American CUTTING (1933) as also by the Italians JAYLE (1942) and SAVARESE (1942) who uses a transverse incision in the area of the rectus sheath, when necessary enlarging it laterally in the direction of the fibers of the internal oblique and the transversalis without injury to the bloodvessels or motor nerves. He states that the ilio-inguinal and the iliohypogastric nerves remain uninjured in case the incision is not extended too close to the spina, neither do incisional herniae occur.

4. *Longitudinal incisions.*

Median incisions.

The incision is made in the area of the linea alba and it divides all abdominal coats in the same plane.

The median incision cannot be considered a true appendectomy incision but a general incision which can be used also in appendectomy. According to literature the first appendectomy in the world was performed by KRÖNLEIN in 1884 (1886) through a median incision. The reason why KRÖNLEIN used this incision is probably that a median incision was, as a rule, at that time the »method of choice» in laparotomy. The first abdominal surgeons used median incision (BIER 1917). Already DIEFFENBACH (1848) in his textbook on surgery recommends a linea alba incision in case no special reason demanded penetration of the abdominal wall at some other point. SPENCER WELLS (1866, 1874) also always made an incision to the linea alba, and MIKULICZ (1903) and KAUSCH (1903, 1920) defend it as a physiological abdominal incision which does not result in incisional hernia when sutured aseptically and thoroughly in layers. TURUNEN (1934) places the median incision foremost in gynecology if only the peritoneum is sutured according to KRITZLER (1924), viz. seroserosally, and other layers well adapted.

SPRENGEL (1906) recommends median incision in appendectomy only when the diagnosis is uncertain, or in cases of appendicitis with peritonitis or other complications. WEISSCHEDEL (1909) advises the use of median incision particularly in appendectomies on women when the interior genitals are at the same time affected. Like SPRENGEL, LEHMANN (1941) also supports the use of median incision in cases of appendicitis or appendicitis with peritonitis in which the diagnosis is uncertain, and in which quick action is essential owing to poor general condition of the patient. The median incision is also easily enlarged without injury to nerves or muscles. A disadvantage of this incision is slow healing due to its being located in an area with poor blood supply and strong muscular tension which may easily cause wound separation. According to TURUNEN this risk is not present in carefully sutured wounds healed by the first intention, and incisional herniae occur only in 0.4 per cent of such cases. (TURUNEN's material comprises gynecological cases.)

In earlier years the technique of suturing was, however, not sufficiently developed to prevent herniation, but the frequency of incisional herniae lead to a more common use of lateral longitudinal incisions in appendectomy, first transrectus and later pararectus incisions (BIER 1917).

Paramedian incisions.

Paramedian incisions divide the abdominal layers laterally of the midline but near it.

Beginning from 1898 LENNANDER used a paramedian incision alongside with the lateral pararectus incision. Having split the anterior rectus sheath 0.5 to 1 cm from the linea alba laterally, the border of the right rectus was freed, and the muscle was displaced laterally. The posterior sheath was opened at a corresponding point. The peritoneum having been sutured, the rectus muscle was replaced and fixed with an interrupted suture, and the anterior sheath was closed. This incision afforded ample exposure, sparing also vessels and nerves as well as the muscle which protected both wounds in the rectus sheath against rupture. There were hardly any incisional herniae following this incision.

LENNANDER's paramedian incision was much praised among others by LAKE (1921). He made, however, the skin incision and also

the peritoneal incision farther from the midline than did LENNANDER, viz. at the border of the inner and middle third of the rectus muscle. An important feature of the paramedian incision is, in LAKE's opinion, the fact that it affords an extremely good general view of the whole abdominal cavity as the percentage of erroneous diagnosing in appendicitis is comparatively large (10—20 per cent in acute and 20—30 per cent in chronic cases). No incisional herniae occurred in LAKE's cases (300).

INGLESSIS (1926) recommends the use of LENNANDER's paramedian incision both in drained and undrained cases. He stresses the following merits of this incision: 1) There is good exposure of the abdominal cavity even through an incision of 5—8 cm only; the peritoneal wound is easily retracted as the fibers of the aponeurosis are cut across. 2) The site of the incision can be chosen in accordance with the demands of each separate case without damage to the abdominal muscles. 3) The incision does not injure vessels or nerves. 4) It is made into a portion of the abdominal wall which comprises numerous layers and through contraction the uninjured rectus muscle will prevent excessively hard postoperative suture-tearing tension by the flat abdominal muscles, or the injurious influence of increased intra-abdominal pressure. 5) The incision is simple and closure is easy. INGLESSIS states the only disadvantage to be the fact that LANGER's lines are not considered, which affects the cosmetic result. In POPOVIC's opinion (1933) the posterior sheath should at least be divided transversely in paramedian incisions.

SKLJAROV (1927) supports LENNANDER's paramedian incision because it does not injure nerves as does the pararectus incision. SKLJAROV considers a small oblique incision to be the best, but as it cannot always be determined in advance whether adhesions are present, LENNANDER's paramedian incision should be employed.

Pararectus incisions.

Since 1893 LENNANDER, according to his own statement, used an incision which he made through the rectus muscle to the affected appendix. HAGEN-TORN (1884) used a similar incision as early as in 1884. LENNANDER abandoned, however, this »extramedian» incision when he noticed, three years after the operation, that the portion of the rectus muscle situated medially of the incision, showed

atrophy due to nerve injury. This incision was also comparatively frequently followed by herniae owing to the fact that the incisions of the different abdominal layers were all in the same ventrodorsal plane, and gave way to an increased intra-abdominal pressure. It should be mentioned that, according to literature, this incision is still employed alongside with other incisions in America. LENNANDER in 1896 started employing an appendectomy incision which he made 0.5–1.5 cm medially of the lateral border of the rectus muscle in accordance with the assumed location of the appendix. Being particularly careful not to injure the connective tissue of the ventral surface of the rectus sheath with its rich supply of bloodvessels, he freed the rectus muscle, displacing it laterally. He thereupon ligated the bloodvessels with thin catgut, and turned visible nerves carefully aside. The dorsal sheath was next opened at a point corresponding to that on the ventral sheath. At the end of the operation he closed the dorsal sheath with a continuous catgut suture, fixed the rectus muscle to the edge of the rectus sheath with an interrupted suture, and closed the ventral sheath with a continuous catgut suture. In his opinion an incision of 6–7 cm is generally sufficient.

At the same time as LENNANDER started using this so-called lateral pararectus incision, some other surgeons independently of each other, had tried it in appendectomy cases. Literature mentions particularly the American KAMMERER (1897) who used this incision under the name of »trap-door» incision, and the Frenchman JALAGUIER. So the names of these three surgeons are mentioned in connection with the »trap-door» incision.

According to literature the lateral pararectus incision was first used by the Englishman BATTLE in 1895 who, at a meeting of the Clinical Society of London presented a case, a patient aged 18, on whom he had performed an appendectomy using the lateral pararectus incision described above. BATTLE had generally used an incision which he made into the area of the semilunar line without opening the rectus sheath, and dividing all abdominal coats by one incision. Having noticed the frequent occurrence of incisional herniae he changed to the area of the rectus sheath.

As a complement to the lateral longitudinal incisions an incision recommended by SCHÜLLER in 1899 should be mentioned. He made

it into the area of the flat abdominal muscles in the course of the linea alba at a point one finger's breadth medially from the mid-point between the spina ilica ventralis and the symphysis. SCHÜLLER paid no attention to the anatomical conditions of the abdominal layers, using the incision in such cases of appendicitis where the cecum was adherent. This incision permits direct approach to the normal site of the appendix. This method has not, however, been extensively used in appendectomies because of the great danger of incisional herniation.

Modifications of the pararectus incision.

BELLEY (1913) suggested the skin incision to be made about 12 cm in length laterally and downwards medially. Retracting the medial edge of the wound he divided the external oblique parallel with its fibers, next opening the rectus sheath and continuing according to LENNANDER. BELLEY considered drainage to be easily performed through this incision and incisional herniation did not occur.

BAKKAL (1929) reports the use of almost a similar modification in his appendectomies.

Pararectus incisions outside the rectus sheath were employed i.a. by BATTLE (p. 27), WYETH, BÜRGER, KROGIUS and GIARDANO.

In cases of periappendicular abscesses WYETH (1902) made a long incision to the semilunar line. He divided all abdominal layers in the same ventro-dorsal plane. In his opinion the danger of this wound becoming infected was smaller than when using the muscle-splitting incision.

BÜRGER (1914) in purulent appendicitis with peritonitis used a pararectus aponeurosis incision, dividing all abdominal layers in one plane.

KROGIUS (1922) made an oblique skin incision laterally and downwards medially the center of which lies in McBURNEY's point. He pierced the aponeurosis of the external oblique in the same direction, and next longitudinally the deep abdominal muscles at the point where they change into rectus sheath and, finally, the transversalis fascia and peritoneum in the same direction. KROGIUS used this incision particularly in diffuse peritonitis following appendicitis and for the acute stage in other operations. In KRO-

GRUS's incision, the incision of the skin and of the aponeurosis of the external oblique on the one hand, and that of the deep abdominal muscles and the peritoneum run crosswise.

The Italian CARISI (1923) describes GIARDANO's »paramedian appendectomy». GIARDANO made a longitudinal incision at the midpoint between the rectus border and the spina ilica ventralis, carrying it through the skin, the subcutis and the aponeurosis of the external oblique. Next he divided the muscular fibers bluntly, again splitting the deep abdominal muscles, the transversalis fascia and the peritoneum through a longitudinal incision. Closure in layers. According to CARISI this incision affords ample exposure of the abdominal cavity facilitating also the differential diagnosis. Drainage is also simple from the lower end of the wound. CARISI states incisional herniae to have occurred only in 2.5 per cent of the cases.

5. *Lumbar incisions.*

The denomination, »lumbar incisions» refers to all incisions the greater part of which are situated laterally of the anterior axillary line.

VISCHER (1897) recommended, particularly in purulent and undrained cases, an incision running from the outer border of the external oblique 1 cm above and parallel to the crista ilica, reaching as far as to the spina ilica ventralis or a little further. The fibers of the external oblique having been bluntly divided, the internal oblique and transversalis are freed in the direction of their fibers. Finally the transversalis fascia and the peritoneum are incised longitudinally. According to VISCHER incisional herniation did not occur as a result of this incision and retrocecal appendices were easily found.

MEUCCI (1921) also used, particularly in purulent retrocecal cases, lumbar incision, as the free abdominal cavity will not be infected by this method and drainage is simple. Due to the thick muscular layer incisional herniation is rare.

The Frenchman LECÉNE (1922) did also support the lumbar incision which he made in accordance with VISCHER and on the same indications. The only difference was that he opened also the peritoneum transversely and not longitudinally.

MEYER (1925) recommended a lumbar incision also in cases of retrocecal appendix. He made the incision sharply through all abdominal layers starting halfway between MCBURNEY's point and the spina ilica ventralis continuing upwards and backwards. After MEYER's appendectomies incisional herniae did not even occur in drained cases. MEYER recommended this incision also after the closure of a pararectus incision if the appendix due to an abnormal position could not be approached that way, and advised an extension of MCBURNEY's incision as described, upwards and backwards.

KRJUKOV (1927) advised, in cases when the appendical abscess was situated laterally of the cecum or the ascending colon, the use of the lumbar incision as in such a case drainage from an anterior incision is difficult. He made a skin incision parallel to and 1—2 cm above the crista ilica. The borders of the external oblique and latissimus dorsi were separated and the lamina profunda of the lumbodorsal fascia longitudinally split, the transversalis fascia and peritoneum being incised next.

HÄRTEL (1931) recommended, particularly in cases of peripandicular abscesses, and MARBURY (1938) in cases of retrocecal appendix, the use of lumbar incision.

SORESI (1931) employed a lumbar incision in all appendectomies as this incision facilitates location of the base of the appendix even in cases with extensive adhesions. By this method the adhesions are preserved and spreading of the infection into the free abdominal cavity does not occur. When an abscess is present drainage is simple.

Particularly for appendectomies during pregnancy MERMINGAS (1931, 1932) recommends a method of lumbar incision. He made the skin incision in the direction of the line between the spina ilica ventralis and the twelfth rib to the middle of that line. Next he divided bluntly the muscles of the abdominal wall parallel to their fibers, taking care not to injure the lateral epigastric artery and the iliohypogastric nerve. The only disadvantage of this method is, in his opinion, the fact that the adnexa cannot be seen.

SAINT (1941) employed a lumbar incision which began at the lateral end of the incision described by MERMINGAS, and continued in the direction of the inguinal ligament to a length of about 10—12 cm. He considered the merits of this incision to be the same as those of other incisions of this type.

Principles of Modern Appendectomy Incisions Particularly in the Light of Incisions Comprised in this Investigation.

Two different types of incisions stand out prominently among the many incisions described in the foregoing, and they have in Europe still maintained their position in the front row of appendectomy incisions. These are the gridiron and the pararectus incision. In spite of their disadvantages their positive qualities are so outstanding that other incisions have not been able to surpass them. Both are used to about the same extent.

SPRENGEL in 1910 made an enquête in order to find out which incision, for instance in appendectomy, was considered the foremost by German surgeons of that time. According to the answers 28 per cent of the surgeons used a pararectus incision and 27 per cent the gridiron incision. 25 per cent of those who replied used alternatively both these incisions depending on the character of the case. According to BURCKHARDT the pararectus incision was in 1939 perhaps the most popular appendectomy incision. At this moment the muscle-splitting incision is here probably the most frequently used incision in appendectomy. BAUER assumes that the muscle-splitting incision with its modifications was the most popular incision in Sweden in 1933.

According to the newest American literature a much more critical attitude is held in America towards MCBURNEY's incision than in Europe. THOREK (1946) among others, states that he has altogether discarded the use of the MCBURNEY incision. In his opinion this incision is even dangerous and has no merits and many disadvantages. »It should be of historical interest only.» Also ROMANIS & MITCHNER (1944) consider MCBURNEY's incision suitable only for opening periappendicular abscesses.

WIDERØE (1927) reports that in Norway the use of the pararectus incision has gradually become less frequent.

In judging MCBURNEY's incision on the basis of the extent to which it fulfils the general requirements of a good abdominal incision we find its negative qualities more predominating than is generally admitted. MCBURNEY's incision is carried through to the abdominal cavity parallel with the fibers of muscles and aponeuroses of the different layers. DRÜNER states that, when pene-

trating the aponeurosis of the external oblique, 3—4 nerve branches depending on the length of the incision, at its lower end, are injured as the direction of the motor branches supplying the external oblique which higher up is the same as the direction of the intercostal nerves and muscular fibers, becomes steeper the lower they run, finally running perpendicularly to the fibers of the aponeurosis. The condition is the same in the area of the internal oblique and the transversalis. If the deep abdominal muscles are pierced in the course of the fibers of the internal oblique, without particular attention being paid to the direction of the fibers of the transversalis, motor nerves running into the rectus muscle, will be injured in this area. A further disadvantage of this incision is frequently stressed, viz. that it does not allow a sufficient general view of the abdominal cavity. The incision must therefore often be enlarged, which results in the sacrifice of more muscular or aponeurosis or nerve fibers. Many suggested and practised methods of enlarging MCBURNEY's incision have been described in the foregoing.

MCBURNEY's incision has, on the other hand, the following merits: The site of the incision corresponds to the normal location of the appendix, it is easily made and closed, and drainage is simple from its lateral end. After removal of the drain the tension of the muscles running in various directions closes the drainage tract, and theoretically the danger of incisional herniation is small. Muscle and aponeurosis fibers are generally not cut across.

There are also several disadvantages in LENNANDER's pararectus incision. Particularly when the incision is long and there is hemorrhage in connection with the operation it hampers exposure, and motor nerve branches, running from behind the rectus muscle some distance medially from the lateral edge, may easily become injured. When several nerve branches are injured the result may be a so serious atrophy of the medial portion or even of an entire segment of the rectus muscle that the rectus sheath contains but an extremely thin disc (DRÜNER 1934). Here the aponeuroses of the lateral abdominal muscles lose their insertion, retracting laterally and atrophying. Defects occur in the abdominal layers which continuously protrude and become thinner due to intra-abdominal pressure. This defect which cannot even be operatively adjusted,

disables a labourer for work. DRÜNER mentions that he found six such cases which are, however, nowadays extremely rare.

As an advantage of LENNANDER's pararectus incision it should first be mentioned that it allows a good general view of the abdominal cavity. It is also easy to enlarge, to close and to drain. Further, muscles are not injured even though the aponeuroses are divided longitudinally in the course of their fibers. Through careful operation, injuries to the nerves may be totally avoided as they are fairly clearly distinguished and may be retracted laterally by means of a spatula. The circulation of blood in the area of incision is also rich which favours rapid healing of the wounds. The uninjured rectus muscle offers good protection for the sutures in the anterior and posterior rectus sheath both against the injurious influence of the intra-abdominal pressure and also against spreading of infection. The protective influence of the rectus muscle is extremely important also in drained cases, as the rectus muscle, after removal of the drain, retracts to the right which results in a curved drainage tract, provided that the drainage has not been prolonged so as to cause loss of elasticity of the rectus muscle. According to investigations performed by AMBERGER (1906) the elasticity of the tissues may repair the damage done by the drains to the abdominal wall till one week later.

The merits of KROGIUS's pararectus incision which defends its position among appendectomy incisions, is the fact that it is easily and quickly made, allowing ample exposure of the abdominal cavity. It is adapted for cases in which rapid interference due to poor general condition of the patient is necessary, or in which the diagnosis is uncertain. It is situated, however, in an anatomically weak spot being located entirely to the area of the aponeurotic abdominal wall. In performing the incision fibers of different aponeuroses are incised either obliquely or across, and nerve branches are difficult to distinguish in this area and so may easily also be damaged. Even though the wound is closed in layers with as careful suturing as possible the danger of incisional herniation is great as no muscles protect the aponeurotic scar. Particularly in cases drained due to infection, in which, after removal of the drain, a fairly straight tract connects the abdominal cavity with the scar in the skin, frequent occurrences of incisional herniae may be expected. True, in KRO-

crus's original incision the skin incision together with the incision of the aponeurosis of the external oblique crossed the incision of the aponeurosis of the deep abdominal muscles, the transversalis fascia and the peritoneum, yet this hardly improves the situation greatly.

Incisional Herniae.

The demands put on an abdominal incision aim principally at the best possible results of the operation and at limiting the possibilities of postoperative complications to a minimum. It is naturally most important that attention is first of all paid to the cure of the original disease, as pointed out by SPRENGEL (1914), but surgical rules must be followed as strictly as possible in order to obtain in every respect a good final result, and to avoid complications the repair of which may prove much more difficult than the removal of the original affection. This is, for instance, the case with regard to incisional herniae and mechanical intestinal disturbances. Experience has taught us that operative treatment of such complications gives comparatively poor results.

I shall in the following first deal with the question of incisional herniae as treated in literature.

1. Definition of incisional herniae.

According to SPRENGEL the term incisional hernia denotes: »Durchtritt von Peritoneum und Bauchinhalt durch eine postoperativ entstandene Lücke der Bauchwand.« — Thus an incisional hernia has a distinct orifice, neck, and sac like an ordinary hernia, and occurs in an operative scar.

Besides incisional herniae so-called paralysis and stretching of the abdominal layers may occur postoperatively. Paralysis of the abdominal layers is, according to SPRENGEL, the result of »funktioneller Ausschaltung eines muskulären Apparates infolge operativer Verletzung der zugehörigen Nerven«.

Stretching of the abdominal layers may occur posterior to a normally developed scar in the skin, or the scar may also be stretched. This group comprises also so-called rectus diastasis.

Paralysis and stretching of the abdominal layers may thus cause bulging without any distinctly limited orifice or other characteristics of hernia.

2. Causes for the occurrence of incisional herniae and bulging.

Factors influencing the occurrence of incisional herniae are, in the first place, the incision used for the opening of the abdomen, the technic of suturing and the suture material as well as the general skill of the surgeon. There are further a number of factors of a predisposing nature which may lead to the occurrence of incisional herniae such as, for instance, wound infection and injury to the wound edges, drainage of the abdominal cavity through the operation wound, postoperative meteorism, vomiting and coughing, the constitution of the patient, his age, profession and sex, as also resuming work too soon after an operation.

Important factors in the relation of an incision to incisional hernia is its relation to the tissues of the different abdominal layers, to motor nerves, bloodvessels, muscles and their aponeuroses, and to the peritoneum.

Injury of motor nerves and bloodvessels.

If the incision cuts motor nerves the result will be atrophy of that portion of the muscle which lies medially of the incision. There will be a limited bulging, a weak spot in the abdominal wall which contributes to the occurrence of an incisional hernia only in case the surrounding fascia or aponeurosis are injured. All lateral longitudinal incisions cut the motor nerves running between the transversalis and the internal oblique in the course of the fibers of the former, to the rectus sheath. So the nerves of the rectus sheath and the rectus muscle are also injured in a pararectus incision in which the muscle is displaced medially (ASSMY 1899). On the other hand a lesion of a couple of nerve branches need not cause muscular paralysis as particularly the motor nerves below the umbilicus anastomose readily, as pointed out by DRÜNER (1921).

DRÜNER stresses that care should also be taken not to injure blood vessels. Epigastric vessels in particular should be saved. But even though it would prove necessary to ligate all epigastric vessels it need not result in serious functional disturbances of the rectus muscle as it is also supplied from the side by the intercostal arteries, the capillaries of which join the capillary network of the epigastric vessels. Anomalies may, however, be present and the surgeon should therefore proceed cautiously.

Injury of muscles.

If, however, the incision severs a muscle in cutting it across, an immediate result is hemorrhage and numerous ligations and, according to SEEMEN (1930), the ensuing resorption of products of decomposition strains the system more than is generally believed. Muscle ends must also be sutured, the sutures frequently cutting through. This results in retraction of the ends, the space between the ends being filled up with preperitoneal fat. It may also gradually be filled up with connective tissue but this weak spot predisposes incisional herniation. WALJASCHKO (1913) noticed that filling of the space between the wound edges by connective tissue is not always the worst that could happen. The wound edges may, in fact, atrophy to such an extent that they form a weaker spot than the scar itself. This was often the case in so-called open treatment of a wound, viz. when the wound was imperfectly closed. Similar phenomena could, however, also occur in carefully sutured cases due to retraction of muscle bundles when these had been cut across. In WALJASCHKO's opinion even secondary suturing was of no use. He therefore stressed the importance of careful prophylactic protection of wound edges which would prevent atrophy. He experimented on dogs proving that muscle fibers which were cut across, did not atrophy if an aponeurotic layer was placed on the cut surface, this layer growing with the muscular tissue forming connective tissue.

KUNZ (1940) does not hesitate to cut across the rectus muscle in connection with appendectomy as in his opinion a cut rectus muscle heals well. A new *inscriptio tendinea* is formed which is firm.

There are certain controversies with regard to the different incisions of the area of the rectus sheath. Fibers should, as a rule, not be cut across. However, when, for instance, pararectus incision (LENNANDER) is employed the aponeuroses of the flat abdominal muscles will be cut across, the rectus muscle remaining completely uninjured. In transverse incision of the rectus sheath, however, the superficial incision is made in the course of the aponeurotic fibers, while the rectus muscle must often be totally or partly cut across. According to SRENGEL it is less dangerous to cut a muscle than to sever motor nerves. NOETZEL (1930) also stresses that nerves may not be cut, nor the rectus muscle below the umbilicus.

Incisions outside the rectus sheath and in the direction of the

long axis of the body, cut the fibers of the aponeurosis of the flat abdominal muscles, and more frequently cause wound separation than incisions transversal to the long axis of the body, the edges of which only approximate as a result of the lateral tension of the flat abdominal muscles, a fact also pointed out by DIAKONOV (1907).

An incision of the peritoneum, be it transversal or longitudinal, below the umbilicus, is easily closed due to anatomical conditions. Below the umbilicus and starting from DOUGLAS' line the peritoneum lies on the dorsal surface of the rectus muscle, separated from it by the thin transversalis fascia. The tension of the flat abdominal muscles does not have the same effect as above the umbilicus.

The manner in which the edges of abdominal incisions are united.

The occurrence of incisional herniae is greatly influenced by the manner in which the wound edges are reunited. The through-and-through knotted suture and closure of the wound in two layers employed at the end of the last century did not reestablish the normal anatomical conditions of the abdominal wall.

WINTER in 1895 published together with his pupil SEMMLER an investigation on the technic of suturing. They investigated during the years 1889—1894 the healing of laparotomy incisions of the linea alba in gynecological patients in Berlin. They themselves performed after-examinations of 393 cases, and received information through other surgeons of 129 cases. They noticed that incisional herniae occurred frequently after the use of through-and-through knotted sutures (Durchgreifende Knopfnaht): in 1889 30 per cent, in 1890 29 per cent and in 1891 23 per cent. Healing by first intention was good protection against incisional herniation, but still not quite certain. The best result was obtained »durch isolierte Fascien-naht», which was used by WINTER from 1893 onwards. Out of 216 laparotomies closed in this manner 12 per cent developed incisional herniae. If, however, only such cases are considered which were operated upon according to improved methods, only 8 per cent developed herniae, which were furthermore smaller herniae than those occurring after the earlier method of suturing. WINTER closed the peritoneum and the aponeurosis separately with catgut. The skin and subcutis he closed with interrupted silk sutures applying in addition a continuous catgut suture between them.

ABEL's large investigation published in 1898 had a far-reaching influence on the suturing of abdominal incisions. He wanted to show that the fault which causes incisional herniation, often lies with the surgeon. So-called mass-sutures were, in his opinion, not sufficient and, therefore, he advised closure in layers. That anatomically related tissue layers should be united in suturing was pointed out i.a. also by NEHRKORN (1902) and KSCHISCHO (1904).

WERTHEIM stressed that after appendectomy performed through a transverse incision the wound should be closed in layers with a continuous catgut suture whereas in drained cases, the portion of the peritoneum posterior to the rectus muscle and the anterior rectus sheath may be closed, the part of the wound outside the rectus sheath being left open to allow tamponage and drainage.

In 1910 v. BRUNN published after-examinations at the v. BRUNN Clinic from the period April 1, 1904 to August 1, 1908 which was a period of transition from open wound treatment to the so-called REHN's closed method. Here the abdominal layers were closed as far as to the drainage tract. The main part of the cases of the after-examination were originally operated through LENNANDER's pararectus incision, and the remainder through lateral oblique incisions. In so-called clean quiescent and early operations no herniae occurred. Other results of the investigation were:

Open wound treatment ..	16	cases	11	incisional	herniae	68.75%
Suture in layers to the						
drain	54	»	10	»	»	18.52%
Periappendicular absces-						
ses and appendicitis						
with peritonitis oper-						
ated according to						
REHN	47	»	16	»	»	21.28%

GARLOCK (1929) expresses as his opinion that in cases of appendectomy requiring drainage, the abdominal layers should not be closed because necroses caused by fascia and muscle sutures will invite incisional herniation. He arrived at this opinion based on after-examinations made in New York of appendectomy patients. The main part of the cases included in his statistics was operated through MCBURNEY's incision and the remainder through pararectus incisions:

264 drained cases, no sutures	17 herniae	6.4%
295 » » fascia, muscle or skin sutures	45 »	15.0%
216 undrained cases primarily closed	0 »	0.0%

DIKANSKIJ (1930, 1931) recommends, in cases of peritonitis following appendicitis, only suturing of the peritoneum and tamponage of the wound, while STOCCADA (1941) closes all layers except the skin. KULOZIK (1926), DIONISI (1927), PYSCHNOV (1926), TONENBERG (1927) and SLAWINSKI & OSTROWSKI (1933) recommend primary closing in layers of the abdominal cavity also in purulent cases originating from the appendix. In this way, according to SLAWINSKI, the occurrence of incisional herniae decreased in the Warsaw »Kindlein Jesu» Hospital during the period 1928—1933 to 1.4 per cent. In suturing attention was paid to careful adaptation of the wound edges, and physiological incisions were used, such as the transverse and oblique lateral incisions as well as paramedian incisions.

Suture material.

The firmness of the scar depends naturally to a large extent on the suture material used for the closure of laparotomy wounds. The quality and thickness of the thread must be well adapted to the tissue in question, the tension etc. The suture material may not be absorbed until the separated tissues of the abdominal wall have united firmly. TURUNEN in 1934 published an investigation on the healing of principally gynecological laparotomy wounds (median and Pfannenstiel incisions). (His material comprised only 1.4 per cent of appendectomy incisions.) However, as the biological process in laparotomy incisions performed for various reasons, is the same as regards the suture material and the wound, the result obtained by TURUNEN may also be applied to appendectomy cases. According to TURUNEN the absorption of catgut is slow enough to allow sufficiently secure healing of the abdominal incision. His histological examinations showed that catgut was completely decomposed by the tissues in 20 days, the edges of the incision of the aponeurosis having cicatrized organically in 11 days, and regeneration also being completed. A condition for firm uniting was naturally careful adaptation of the wound edges in suturing. In suturing the perito-

neum and the aponeurosis this result is best achieved by means of a continuous sufficiently close suture, whereas it did not matter if interrupted or continuous suture was employed in the muscular layer.

Regarding the products of decomposition of the suture material and its influence on the scar, TURUNEN established that catgut left only a thin connective tissue streak whereas MASSON (1923) had already earlier observed that the connective tissue formation caused by silk sutures was considerably greater than that brought on by catgut, and that this scar did not stand tension as well as did the scar of a wound sutured with catgut.

Operative technique.

As already mentioned in connection with WINTER's statistics (p. 37), besides the method of suturing, the general operative technique is also of great importance. A skilful surgeon obtains better results in every respect with regard to the quality of the scar. This appears clearly also from TURUNEN's statistics mentioned in the foregoing, in which similar operations performed by the head surgeon and by young assistant surgeons could be treated separately. The percentage of incisional herniae was 0.2 in the former operations and 2.3 in the latter.

Drainage through abdominal incisions.

Drainage has been generally experienced to increase the danger of incisional herniae in the treatment of peritonitis and to play a rôle in the occurrence of mechanical intestinal disturbances, as do also methods of washing and disinfection of the abdominal cavity performed either simultaneously with the drainage or separately.

Historical survey of the stages of drainage, of washing of the abdominal cavity and of disinfection.

The drainage being injurious even to the healing of an incision of the abdominal wall the question arises whether it is worth while to drain at all, viz. whether greater advantages than disadvantages for the curing of the patient are obtained by drainage. This problem was subject to numerous experiments and discussions in the surgical world as early as the end of the last century. As drainage has been employed to a considerable extent in our country, and as the cases included in my investigation

are all drained, I shall in the following briefly relate the general aim of drainage and the results obtained through it as well as the after-effects resulting from it.

As for different types of drains and tampons, these have been described i. a. by KROGIUS (1901, 1905, 1912), G. BAUER (1933) and CANDOLIN (1936) and I shall therefore not deal with them in this connection.

The purpose of drainage in cases of peritonitis was to remove the pus deposited before the operation as well as the exudate accumulating post-operatively, and to limit the inflammatory focus from the sound areas of the abdominal cavity. Based on the experiments of WEGNER (1876) one knew that the peritoneum is highly absorptive. Animal experiments had shown that from the abdominal cavity the peritoneum was able to resorb fluid up to 3.3—8 per cent of the body-weight within one hour. In cases of peritonitis the exudate contains bacteria and toxins, and consequently it was believed that resorption would result in general infection or intoxication. The peritoneum and the exudate produced by it was also known to possess the power of destructing bacteria. Should, however, the virulence or the number of bacteria be very high they would be beyond the capacity of the peritoneum. Therefore, the exudate was for safety's sake drained out of the abdominal cavity. During the early days of surgical treatment of peritonitis, abscesses of the soft tissue were treated by means of large incisions, washing and tamponage. Efforts were made to adapt the same method also for the treatment of the abdominal cavity. The result was a method of treatment which was frequently followed by residual abscesses, as pointed out by OBERST (1885), and the free abdominal cavity still remained undrained. At the end of the last century MIKULICZ (1881) described his own method of drainage which has been both highly praised and much criticized. In accordance with the original method the abdominal wound was left open. ISRAEL'S (1897) method of drainage should also be mentioned. He opened the abdomen by a large transverse incision, and left it completely open covering the intestines only by an iodoform tampon. He was satisfied with his results.

According to statistics published by KROGIUS in 1901 the mortality in cases of peritonitis was at that time large (71.5 per cent). Further a large number of cases of postoperative ileus, intestinal fistula, prolapse of the intestine and incisional hernia occurred due to the fact that the disease was far developed before the arrival of the patient for treatment, and because of the open treatment of the wound. Besides, the removal and changing of tampons was extremely painful to the patient, requiring sometimes even renewed anaesthesia.

It was, however, soon observed that the plasticity of the peritoneum established by WEGNER in his experiments, hampered effective drainage. YATES in his many-sided experiments showed in 1905 that adhesions occurred around the drain already within about 6 hours separating it completely from the free abdominal cavity. YATES experimented on healthy animals but presumed the formation of adhesions to be still more rapid

in cases of peritonitis. Besides, fibrinous clots sometimes occluded the drain allowing no fluid to pass. Consequently the drain only acted as an irritant causing adhesions which could later result in various kinds of complications.

Even though YATES proved the impossibility of draining the free abdominal cavity, drainage and various problems connected with it have continuously and up to the present time been subject to intense investigations. Surgeons hold very different views with regard to drainage of the abdominal cavity.

Supporters of drainage.

In 1902 REHN described a method of draining which in spite of opposition has, until quite recently, found eager support. In cases of peritonitis he washed the abdominal cavity as thoroughly as possible with saline solution, and placed a thin rubber drain in the lowest pelvic pouch¹ closing the abdomen in layers as far as to the drain. The patient was kept in FOWLER'S position during the entire duration of the drainage, hips lower than the upper part of the body.

ROTTER (1910) in 1909 attacked REHN'S method quoting REICHEL'S investigation published in 1890 in which the latter states that »Spüleri ist Spielerei». In ROTTER'S opinion the drain as a foreign body, just acts as an irritant causing adhesions, and only residue of the washing solution escapes through the drain. ROTTER further states that in case the residue of the washing solution is dried up with sponges at the end of the operation from the lowest pelvic pouch, nothing escapes through the drain. ROTTER stressed that of greatest importance is early interference, removal of the inflammatory focus and thorough cleansing of the abdominal cavity which is best done by means of washing. Washing he employed, however, only when the pus was particularly thick and he drained only very severe cases of peritonitis.

PROPPING (1910), on the other hand, who performed experiments for the measuring of the intra-abdominal pressure, supported REHN'S method. In his opinion the effect of the DOUGLAS drain was in the first instance based on the hydrostatic pressure which, when the patient was held in FOWLER'S position, was greatest in the pelvic region. Thus the increased intra-abdominal pressure in peritonitis also added to the effect of the drain. As late as in 1927 PROPPING defended his viewpoint based on clinical experience and physical principles. In his opinion drainage of the free abdominal cavity is possible by means of REHN'S method, viz. DOUGLAS' drainage. He further stressed that the inclination in FOWLER'S position

¹ I have sometimes used the denomination »fossa Douglas» for the lowest pelvic pouch, as also »DOUGLAS' drain» for a drain applied to it. However, fossa Douglas indicates the rectouterine pouch and consequently this term cannot be used for men as they have a rectovesical pouch only. Although the terms DOUGLAS' drain and fossa Douglas are not quite correct, I still avail myself of them as their use has become a habit in medical science.

may not be so steep that the hydrostatic pressure difference between the abdominal cavity and the drain becomes too great, in which case a coil of intestine might adhere to the opening of the drain. According to PROPPING adhesion of the drain to the surrounding tissue does not occur until there is no accumulation of fluid in the lowest pelvic pouch.

In 1926, when the problem of drainage was discussed at the German Surgical Congress, KIRSCHNER had expressed his opinion as follows: »So ist die Drainage der freien Bauchhöhle im besonderen ihr letztes Überbleibsel in Form der Douglasdrainage nichts anderes, als die letzte, aber unnötige Krücke unserer übertriebenen Gewissenhaftigkeit.« Because of this point of view PROPPING expressed his opinion as already mentioned, and also NOETZEL in 1927 and 1940 raised his voice to speak in favour of drainage. He maintains that as long as there is fluid in the abdominal cavity, even though the pressure be small, it can be withdrawn. In this connection he refers i. a. to DOUGLAS's drainage. He does not support prolonged drainage, but he states that infectuous and toxic products must and can be removed from the abdominal cavity. The statements that the drain causes adhesions is, in NOETZEL's opinion, incorrect. He for his part maintains that adhesions occur more readily in cases of peritonitis in which the purulent abdominal cavity was not surgically treated.

The importance of REHN's method for drainage is also stressed by KÄTE MÜLLER in 1939. She mentions that it is still employed in the Hospital of the Danzig Deaconess-House where all cases of peritonitis are drained according to REHN's method, which, in their opinion, is better than other methods of drainage or primary closure of the wound. Since 1926 no DOUGLAS's abscesses occurred in their hospital, neither did they notice any other injurious results of the rubber drain.

In the question of drainage MURPHY who in 1908 described his method of treatment of peritonitis, represents his own line. He did not wash nor dry the peritoneal cavity but, in connection with the operation, he let part of the exudate flow out through inclining the patient and, having applied a thin rubber drain, he closed the abdominal layers completely to the drain.

There has thus been greatly diverging opinions on the effect and importance of drainage. When studying literature it sometimes seems as if many authors who published investigations on drainage, were not very well acquainted with earlier results of investigations in this branch. Different methods of drainage have and still have eager supporters. Thus MIKULICZ's method of open drainage which, according to KROGIUS, in severe cases of peritonitis resulted in a high mortality, was as late as in 1925 eagerly supported by FAURE, and in 1941 JACKSON & PERKINS also leave the wound open in operations for peritonitis, draining the lateral portions of the pelvis and the abdominal cavity. PAPP & TEPPERBERG in 1936 speak keenly in favour of MIKULICZ's drainage. According to them its draining effect is as high as possible yet without irritating the peritoneum too much. In their opinion the drain localizes the infection, fixes the

toxic products as well as stimulates both the general and the local power of resistance. »Die virulenten Erreger einer eiterigen Peritonitis warten nicht darauf, nach aussen geleitet zu werden, sondern wollen an Ort und Stelle vernichtet sein.« PAPP & TEPPERBERG stated that, in their opinion, a rubber drain did not fulfil their requirements of drainage.

SOSTEGNI (1938) further speaks in favour of drainage according to MIKULICZ. He considers it the most reliable drainage and he noticed no adhesions nor intestinal fistulae. It should be added, however, that PAPP & TEPPERBERG and SOSTEGNI closed the abdominal layers, as was the custom since the time of KROGIUS, in connection with MIKULICZ's drainage.

PETROFF (1913) and ADAMS (1914), among others speak in favour of drainage in general. They believe themselves to have proved that drainage is possible in peritonitis about 2 days after the operation. If drainage is prolonged, the drain may cause a secondary infection by irritating the intestine and allowing colon bacilli to pass through the injured intestinal wall into the abdominal cavity. SASSE (1914) establishes that the peritoneum is well able to subdue a primary infection even though it be strong, but if there are infiltrated spots and granulation tissue with continuous secretion, the bacteria of the peritoneal cavity will find in it good soil for reproduction and the peritoneum will not be able to overcome the infection. According to SASSE this is the state of things from the third day of the peritonitis when the abdominal cavity should be canalized.]

Among others ALBRECHT (1923) arrived at the same result. He found that the physiological resistance of the peritoneum lessened about 48 hours after the onset of the infection. Therefore, in early operations he closed the wound primarily in purulent peritonitis, draining always when the case was brought for operation as late as on the third day.

SASSE's and ALBRECHT's opinions were supported also by v. FAYKISS (1930), MOEN (1932), ZAFFAGNINI (1933), DE FRENELLE (1934), NEWTON and HANFORD & SZABO (1939). SEITZ (1920) on the other hand always applied drainage in purulent peritonitis during the first two days following the operation, allowing removal of the drain only the third — fifth day. He made experiments in order to establish the changes in the amount of bacteria in peritonitis and he found, in pus removed through the drain, that the bacteria had increased one day after the operation. On the second day the amount of bacteria was still large, decreasing gradually until, on the third to the fifth day, the pus was almost sterile.

STEICHELE (1922) and ROCKEY (1924), among others were also eager supporters of drainage, the latter applying drainage during 12 hours only, and adding to the effect of the drain by placing the patient in a suitable position. STRAUCH (1926) drained also acute cases of appendicitis if the general condition indicated a serious infection, although the appendix looked harmless. So did also MARGOTTINI (1938).

HANS (1926) and DAVIS (1934) drained only as long as secretion escaped through the drain. BOCREMA related in 1935 that the mortality of cases of appendicitis with peritonitis during the period 1922—1935 in the Uni-

versity Clinic of Gröningen, fell below 0.5 per cent when systematic drainage during 24—48 hours was introduced. DOMANIG (1938) considers drainage indispensable in connection with operations performed because of a perforated appendix. Drainage was employed in the same way by KORZUN (1941) and DRESCHER (1941) who did not find a thin drain to cause any damage nor even incisional herniae.

On supporters of primary closure of abdominal wounds.

Surgeons who employ primary closure of an abdominal incision, trust in the defensive power of the peritoneum, and believe that the free abdominal cavity cannot be drained. The supporters of this line of thought operate generally as sparingly as possible, often even avoiding every kind of removal of the pus from the abdominal cavity in connection with the operation. There are even those who consider the peritoneal secretion to be of great importance as a local vaccine. There the humoral and cellular defense powers of the organism concentrate and fight against bacteria. It is thus necessary for the healing, as was also stressed by CLAIRMONT (1926).

F. BAUER and ROTTER are generally mentioned in literature as the fathers of the method of primary closure of the abdominal cavity, but already MIKULICZ in 1883 and KRÖNLEIN in 1884 had closed the abdominal cavity primarily when operating for appendicitis with peritonitis, as appears from their papers (MIKULICZ 1885, KRÖNLEIN 1886). KROGIUS (1901) considered MIKULICZ and KRÖNLEIN the creators of the modern treatment of peritonitis. However, F. BAUER dictated the conditions which form the basis for the method of primary closure. According to BOHMANNSON (1935) F. BAUER closed the abdominal cavity primarily only when the primary inflammatory focus was removed, draining in the contrary case, or when the abdominal cavity still contains sources for a continuous infection such as abscess walls, necroses, bleeding granulations, hematomata, foreign bodies, coarse unclean matter or tissue the vitality of which is doubtful. They drained in such instances stressing, however, that drainage of the free abdominal cavity was not thus achieved.

Primary closure of the abdominal cavity has since F. BAUER and ROTTER from year to year found new supporters who on the basis of their investigations close the abdomen exactly according to the same principles as did their precursors. Of the supporters of primary closure the following surgeons should i.a. be mentioned: LECÉNE (1922), PYSCHNOV (1926), KRECKE (1926), KULOZIK (1926), SVESNIKOV (1927), SIEBENHAAR (1927), TONENBERG (1927), DIONISI (1927), BUGYI (1929), DIKANSKIJ (1930), MÜLLEDER (1930, 1937, 1942), BALICE (1940), QUERVAIN (1941), MILES (1942), LAUBER & JASPERS (1942). Among those who recommend primary closure in appendicitis with peritonitis in children are BURKE (1930) and TUOVINEN (1935).

Primary saturation is generally considered to lower the mortality and, therefore, the occurrence of residual abscesses, subphrenic in-

flammatory foci, adhesions and incisional herniae is said to have lessened. Besides, the duration of the hospitalization is shorter than for patients with drainage.

Supporters of an individual treatment.

Between the two principal lines presented in the foregoing there are supporters of a more individual treatment who drain or close primarily depending on the case.

Modern views on drainage.

The general tendency with regard to the question of drainage seems to be towards primary closure of the abdominal incisions in operations for peritonitis even in cases where the omission of applying tampon or drainage would earlier have been considered a lack of surgical knowledge. There are, however, still diverging opinions as to drainage, particularly in connection with diffuse peritonitis. G. BAUER in 1933 stated that most surgeons probably support a limited drainage in the form of pelvic drainage. CANDOLIN, on the other hand, is of the opinion that the problem of drainage has been differently solved in different countries depending on the opinion and methods of leading surgeons of the country in question. In the northern countries, for instance, primary closure is more common; in France, drainage is eagerly supported whereas the Germans have chosen a middle course. At the surgical congress in Debrecen in 1938 MATOLCSY said that the only point in the question of drainage about which all are of the same opinion is that abscesses of the abdominal cavity unquestionably demand drainage. PETERMANN in 1939 stresses the opinion that it is less dangerous to apply an unnecessary drain than to omit a necessary one. »Lieber einmal zuviel als zuwenig drainieren.»

On irrigation and disinfection of the peritoneal cavity.

Cleansing of the peritoneal cavity according to different methods in connection with operation is closely connected with the question of drainage.

In the beginning of the period of operative treatment of peritonitis one tried to debilitate the bacteria and toxins and to remove them and unclean matter from the abdominal cavity. An extremely generous quantity of solution, 30—40 l even, was used in washing. By means of antiseptics in the solution one tried to disinfect the abdominal cavity.

KROGIUS (1901) mentions that washings i.a. with thymol, boric acid, phenol and sublimate were administered in the beginning, but these were soon abandoned when cases of poisoning occurred. (Water and physiologic salt solutions were thereafter used).

According to REICHEL (1890) TRZEBICKY in 1886 developed experimental peritonitis in dogs, and obtained good results by washing the peritoneal cavity first with a saline and then with a salicylic acid solution.

WITZEL (1888) made several extensive incisions inserting drains in various directions into the abdominal cavity, and washing through them. REICHEL noticed that healthy dogs showed respiratory and circulatory disturbances, and hematmata in the mesenterium and omentum after peritoneal washings. The peritoneal cavity in dogs with peritonitis could, on the other hand, not be cleansed through washings. The time of operation was prolonged and the animals died anyway. That was why REICHEL stated that »Spülerei ist Spielerei«.

DELBET also established that the abdominal cavity could not be cleansed by means of irrigation, yet he had not noticed dyspnea nor any circulatory disturbances following it. He pointed out, however, that in washings with saline solution transfusion may occur producing an effect of stimulation. He established further that after generous washing of the peritoneal cavity a disinfecting sublimate washing could be administered without toxic result.

In spite of the very diverging results of irrigation of the peritoneal cavity the majority of the surgeons during KROGUS's time employed washing when operating for peritonitis. They stressed its stimulating influence upon the general condition and on the muscles of the parietic intestine.

KÖRTE (1903) stated: »Meine Erfahrungen haben mir gezeigt, dass es kein besseres und kein schonenderes Mittel zur Reinigung der inficierten Bauchhöhle gibt, als energische Spülung mit gut warmen indifferenten Salzlösungen. Durch Eingehen mit Gazecompressen wird die Säuberung unterstützt.«

However, a common feature in all methods is that neither the exudate, nor the bacteria or unclean matter can be completely removed. A frequent result of washing is only injury to the peritoneum, spreading of the infection to a larger area of the abdominal cavity and a prolonged operation. In the same way the serosa has been injured by careless dry methods of procedure and its physiological power of resistance inhibited.

G. BAUER supports an individual procedure in operations for peritonitis, particularly as, according to him, mortality statistics in cases treated by different methods show a difference of about 0.5—1 per cent only.

Modern local and general treatment of peritonitis by means of sulfa-preparations.

After the appearance of BAUER's monograph the treatment of peritonitis and particularly of appendicitis with general peritonitis has taken quite a different course. Washing and drainage has been used less than before and a new weapon against peritonitis has been found in the so-called sulfa-preparations. American and English physicians particularly have described its manner of function and its effect but there are also articles on this subject from other countries.

Statistics on the result of sulfatreatment of peritonitis are, however, so far too small for one to draw any absolute conclusions. Sulfa-preparations seem generally to further healing and to lower mortality, as was shown by ANDERSON (1942) in his statistics. As it has been proved that the sulfa-preparations are effective against all bacteria in appendicitis with peritonitis, and as sulfonamide given by the mouth is absorbed in the peritoneal fluid, there is, according to LASSEN (1943), sufficient reason for the use of sulfa-preparations as an aid in surgical treatment. Considering the power of resorption of the peritoneum and the dissolvability of the sulfa-preparations, these preparations have been administered either alongside with the peroral treatment, or they have been applied alone locally, viz. introduced dry or as a solution in connection with an operation into the peritoneal cavity, mostly into the region from which the appendix has just been removed. The sulfa-powder, particularly when applied dry, has, however, frequently hampered healing resulting in granulation tissue, adhesions and symptoms of intestinal obstruction (SUTTON 1942, HAWKING & HUNT 1942, SAXÉN & TUOVINEN 1947). Sulfonamide is generally resorbed leaving no traces whereas particularly sulfathiazole and sulfa-preparations containing talc sometimes cause these disturbances. Granulomas occur as a result even of generally innocent sulfa-preparations particularly when applied to a peritoneal surface which has been injured in connection with an operation and which is poorly supplied with blood. These granulomas may result in adhesions and mechanical intestinal disturbances, as proved by the rat experiments and the results of the clinical investigations of SAXÉN & TUOVINEN.

It should finally be mentioned that NASSAU & LORRY & PULASKI (1941) and TAYLOR (1942) consider drainage alongside with peroral sulfa-treatment to be the best support in operative treatment. A drain inserted into the area of the appendix fulfils, in TAYLOR's opinion, its task in evacuating the pus and the sulfa-preparations administered perorally have a general effect on the peritoneum. If powder is applied locally into the area of the appendix it will be resorbed there having no effect upon the areas between the intestinal coils or upon abscesses possibly developing subphrenically.

Wound infection.

Wound infection is one of the most important causes of the occurrence of incisional herniae. Infection weakens the scar in the aponeurosis forming a weak spot which immediately gives way to increased abdominal pressure. Wound infection causes catgut to resolve too early and, the suture having opened, a part of the peritoneum protrudes into the wound. Therefore, the aseptic rules must be carefully followed, and incisions should be made so as not to cause ragged wound edges.

According to SEEMEN (1930) even an aseptic operation wound tends to become infected when the tissue undergoes necrosis. There are in the wound mostly bacteria of the skin which find suitable soil for pathologic changes in the necrosing wound tissue. BRUNNER has proved that even though the wound secretion has a bactericidal capacity, the bacteria win when nourished by necrotic tissue. Therefore, SEEMEN warns against mechanical, chemical or heat injury of the wound edges in operating.

Observations on the influence of wound infection on the occurrence of incisional herniae have been made i.a. by the following surgeons:

According to ABEL's (1898) statistics:

If the wound suppurated 2 weeks incisional hernia followed in 40					per cent of the cases
»	»	»	»	3	» incisional hernia followed in 55
					per cent of the cases
»	»	»	»	4	» incisional hernia followed in 65
					per cent of the cases
»	»	»	»	more	than 4 weeks incisional hernia
					followed in 71 per cent of the cases

ABEL's material included cases of median incision, the largest number of herniae occurring at the lower end of the scar, viz. the lowest third, which is frequently the site of infection. ABEL stressed the great importance of asepsis.

SILBERMARK (1903) advised careful removal of all clots from the wound edges and ligation in order to avoid infection.

According to ADLER (1932) purulent peritonitis is followed by phlegmons of the abdominal layers, the formation of which should be prevented both by drainage of the peritoneal cavity and by drainage of the different abdominal layers and washing with rivanol (1: 500).

KING (1941) advises covering of the wound edges with sterile vaseline in infected cases before opening of the peritoneum.

STOCCADA (1941) believes in reducing wound infection in appendectomies, and incisional herniae caused by it by leaving the skin unsutured and injecting his patients with quinine hydro-

chloride, autovaccine or polyvalent vaccine mixed into 5 ccm of milk.

It should also be mentioned that MORIAN (1932) is of the opinion that an appendectomy wound is always more or less infected from within because the intestinal canal must be opened. The wound may still heal primarily as in an aseptic operation if the operative technic has been good and the quantity of bacteria of the operative field not too large.

Postoperative meteorism and increased intra-abdominal pressure.

Postoperative meteorism and generally an increased intra-abdominal pressure was early considered a factor in favouring the formation of incisional herniae. According to WOLFF (1902) postoperative meteorism is of much greater importance for the occurrence of incisional herniae than the method of closure of the abdomen. He pointed out that just these patients who developed incisional herniae, had suffered from postoperative meteorism. In his opinion the suture technic applied in closing the incision was of no importance. Intestinal coils distended due to meteorism, press against the abdominal wall, the pressure against the aponeurosis being greater than against the skin which is more elastic. Due to mechanical reasons and the pressure being sufficiently heavy, the suture of the aponeurosis gives way although the wound appears primarily healed. According to WOLFF drainage impedes the occurrence of meteorism but this opinion was proved, however, to be incorrect. He always applied drainage in cases in which he suspected postoperative meteorism to occur, maintaining that he obtained more secure scars and a considerable reduction in the percentage of herniae. The disadvantage of drained cases healing more slowly than primarily closed ones was, according to WOLFF, trifling.

HAHN (1903) contested WOLFF's statements pointing out that all his cases had healed even though postoperative meteorism occurred. Since 1896 HAHN had performed 88 laparotomies none of which were followed by incisional herniation. The most important matter was, in HAHN's opinion, a closure in layers as thorough as possible with sterile silk which did not resorb as rapidly as catgut.

As to the intra-abdominal pressure in general, PROPPING in his

experiments arrived in 1910 at the result that the local intraperitoneal pressure differs in degree in different places. However, this hydrostatic pressure is equalized on the entire peritoneal cavity as a result of pressure upon the abdomen or when the contents of the abdominal cavity increase to such an extent that tension is present in the abdominal layers as, for instance, in cases of severe meteorism or in pregnancy. According to PROPPING breathing, coughing and vomiting increased the intra-abdominal pressure.

The intra-abdominal pressure (intraperitoneal pressure), according to KEPPICH, is under normal conditions usually less than that of the atmosphere on the abdominal layers. By intraperitoneal pressure he understands the pressure between the abdominal viscera. KEPPICH investigated the intraperitoneal pressure both in healthy and sick animals and in healthy persons and patients suffering from some disease. For his experiments he used a two-branched hydromanometer which was hermetically attached to a so-called Salomon's needle. In connection with laparotomy he introduced the needle through the transversalis fascia and the peritoneum into the abdominal cavity. He tested the hypogastrium in 24 cases. In 17 cases the pressure was reduced in comparison with the atmospheric pressure by 0.4—3.4 cm of the water-column. Breathing, coughing and compression of the abdomen caused no changes in the pressure. In a few cases of appendicitis he noticed that the intraperitoneal pressure had increased in comparison with the atmospheric pressure by 0.6—18.0 cm of the water-column. The greatest increase of pressure was registered in cases in which the appendix was subject to considerable inflammatory changes and in which the peritoneal cavity contained pus and ill smelling turbid fluid. Change of position did not influence the intraperitoneal pressure. KEPPICH in his experiments proved that the intraperitoneal pressure is less than the atmospheric pressure upon the abdominal layers. The pressure varied between 0.4—3.4 cm of the water-column, being almost constant, no noticeable influence of breathing or abdominal compression (Bauchpresse) or position being registered. Owing to sudden inflammations, however, the pressure may increase to as much as 18 cm of the water-column, thus being considerably higher than the atmospheric pressure.

LAM (1939) made experiments in order to determine the intra-peritoneal pressure, and criticized earlier investigations. He stated that by intra-abdominal pressure different authors mean quite different things, thus arriving at such varying results. LAM says that at least 27 different investigations had been published up to 1911 on this subject; four authors stated that the intra-abdominal pressure was atmospheric, six that it was negative, twelve positive and five that it was varying. LAM distinguishes sharply between intra-peritoneal, intravisceral and intra-abdominal pressure. Intra-abdominal pressure is just that which should be considered in connection with hernia investigations and which investigators have tried to determine, but they have made the error of measuring either the intravisceral or the intraperitoneal pressure. KEPPICH's investigation, for instance, does not throw any light upon the question of intra-abdominal pressure because he speaks indiscriminately of both intra-abdominal and intraperitoneal pressure and in his experiments measures the intraperitoneal pressure.

LAM's opinion based on his own animal experiments and on the experiments on human beings performed by other investigators, was that the intra-abdominal pressure is hydrostatic and that it amounts in a person in a standing position to about 25—40 cm water. The pressure decreases towards the upper part of the abdominal cavity, but is negative below the diaphragm. An increase in the intestinal contents adds to the intra-abdominal pressure; however, slight increase in the intestinal contents causes only a reflectional stretching of the abdominal coats allowing the intestines to extend, without increasing the intra-abdominal pressure. LAM mentions that COOMES studied this problem but already KEPPICH (1921) describes BRUNN's experiments on removing the path of this reflex, viz. the semilunar ganglion and the splanchnic nerve, after which filling of the ventricle caused increased intra-abdominal pressure.

GEHRKE (1940) speaks of an aeromechanical explosive effect (die aeromechanische Sprengwirkung) on the laparotomy wounds. Purely physical factors, extreme variations in the pressure changes existing between the lungs and the pleural cavity on one hand, and the abdominal cavity and the atmospheric pressure on the other hand, contribute towards wound separation and eventration in

laparotomy. He considered coughing, blowing of the nose, vomiting, strenuous purging and the sudden rising of the patient in bed to be factors which caused such changes. Fundamental reasons for wound separation are in his opinion pathologic-biochemical factors in connection with the suture material, the technic of suturing, the nature of the affection causing the laparotomy, infection and the constitution of the patient. Hereditary disposition, age and vitamin contents in the food before and after the operation he regards as secondary factors.

Thus, according to literature the intra-abdominal pressure of an individual in an upright position is greatest in the lower portion of the abdominal cavity but decreases higher up. That this is of actual importance to the occurrence of incisional herniae appears, according to AMBERGER (1906) and SPRENGEL (1910), from the fact that even a non-physiological incision in the upper portion of the abdomen is seldom followed by incisional herniae. As an example they mention the non-physiological gallbladder incision parallel with the right costal margin after which incisional hernia occurred only in 8 per cent of the cases. Therefore high location of the incision in the abdominal wall is of great importance to the problem of incisional herniae. Increase of the intestinal contents and also meteorism as well as coughing, sneezing, vomiting, and every activity causing a state of tension in the abdominal muscles, increase the pressure. A considerable increase in the intra-abdominal pressure is brought on, for instance, by labor; this pressure helps the delivery but also the formation of incisional herniae in patients recently operated on.

Length of incision.

The influence of the length of an incision on the formation of incisional herniae has already been dealt with in the foregoing. It has generally been found that the longer the incision the more nerve lesions and consequently also incisional herniae. Thus ABEL's material showed fewer herniae in small scars and vice versa. In LENNANDER's incision, for instance, there are chances of severing 1—11 nerve branches depending on the length of the incision, and in oblique incisions in one plane, and in lumbar incisions there is in addition to other nerve lesions a further injury to the ilio-inguinal and the iliohypogastric nerves if the incision is extended to the

region of the spina ilica ventralis. This is also the case with regard to MCBURNEY'S incision. The length of the incision and the number of nerve lesions are, however, not in direct proportion to each other. If the incision is made in the course of the nerves and between them even a long incision does not injure the nerves.

The age of the patient.

Different surgeons have presented varying statistics as to the influence of age upon the occurrence of incisional herniae. AMBERGER published statistics according to which incisional herniae occurred most frequently in children, and he based this observation on the fact that purulent peritonitis was more common in children than in adults. In statistics published by CAVE (1934) from the Roosevelt Clinic of 5 366 laparotomies, incisional herniae were found in 2.2 per cent of the cases, the greatest number developing in patients of 25 years or more. According to FOWLER (1925), however, incisional herniae occur most frequently in persons of 25—30 years.

Sex.

There are also varying statistics as to the influence of sex upon the occurrence of incisional herniae. According to AMBERGER incisional herniae were twice as frequent in men as in women. Basing his opinion on statistics published in 1934 CARLUCCI arrived at the same result. MASSON (1923) however, who based his arguments on the statistics of the Mayo Clinic, states that incisional herniae are more common in women than in men.

Nutritional condition.

It has been assumed that the nutritional condition also influences the occurrence of herniae owing to the fact that excess of adipose tissue in fat persons may render suturing of the abdominal layers difficult. Fat may penetrate between the sutures particularly in an interrupted suture, furthering the occurrence of incisional herniae. The peritoneum has also been found fragile in fat persons tearing more readily when sutured. Rapid loss of weight has likewise proved to forward the formation of herniae.

Occupation.

The formation of incisional herniae is influenced by the occupation inasmuch as heavy manual labour places greater demands on the firmness of the abdominal layers than light work, the chances for the occurrence of incisional herniae therefore being greater in labourers than in intellectual workers.

Resumption of work after an operation.

The time for resuming work after an operation plays an important rôle in the occurrence of incisional herniae. The operation scar must be firm before heavy physical work is allowed. Intellectual workers may resume work earlier after an operation than labourers.

Clinical Part.

Introduction.

My intention is to ascertain by means of after-inquiries the extent to which incisional and inguinal herniae as well as mechanical intestinal disturbances occur as a result of operations for acute appendicitis or peritonitis following appendicitis. I have particularly tried to find out after which appendectomy incision, commonly used here, the abdominal wall proves most firm. As drainage puts particularly great demands on the firmness of the abdominal scar I have chosen as objects of my investigation only those cases in which the abdominal cavity was drained through the appendectomy incision in connection with the operation. A reason for restricting my work to drained cases only was the extreme difficulty of getting in touch with patients tens of years after their discharge from hospital. As investigators have unanimously inferred that in an ever so non-physiological incision of the abdominal wall the occurrence of incisional herniae is very rare when the incision has been primarily closed, I do not believe that the exclusion of undrained cases from this investigation will to any noticeable degree influence the result.

No revolutionary results should be expected from my work. Already the fact that I have not personally had the possibility

of performing the after-examination of the patients but have obtained information by means of written inquiries, reduces their exactness. My intention is, however, only to compare the three incisions dealt with in the foregoing and I assume the results to be relative, viz. I consider the possibility of errors to be the same for each incision.

Selection of Material.

I have selected for my work cases of acute appendicitis and of appendicitis with peritonitis from the Viipuri County Hospital during the period 1913—1932, from the I and II Surgical Clinic of the University of Helsinki from the period 1915—1932 and from the Maria City Hospital from the period 1905—1932. My original intention was to investigate only the material from the Viipuri County Hospital, but it soon appeared from the records that in cases suitable for my investigation the surgeons of this hospital had extremely rarely employed KROGIUS's incision. As I received only three incomplete replies from the patients, I found I could not use this group in my statistics. In 1937 I therefore sent questionnaires to similar cases from the Surgical Clinic, and this material also being scanty, I made the same inquiries with regard to the material from the Maria City Hospital where KROGIUS's incision was earlier used almost methodically.

My work was greatly hampered and considerably limited by the fact that particularly during the early years the records and operation reports of our public surgical hospitals are very incomplete. I have selected only those cases of acute appendicitis and of appendicitis with peritonitis the records of which have contained all information necessary for my work. Having collected the records which served my purpose, I tried to find the addresses of the patients at that time (in the years 1935 and 1937—1938) through various church registers and through the inquiry-office of the Viipuri and the Helsinki police. However, tens of years after the discharge of the patients from hospital this proved to be extremely difficult due to the change of many addresses and names. My material which was already much reduced due to incomplete records, was thus again considerably restricted. I was therefore able to send questionnaires only to 832 patients out of the 1 237 cases

of the Viipuri County Hospital, to 429 out of the 452 cases of the I and II Surgical Clinic of the University of Helsinki and to 497 out of the 793 cases of the Maria City Hospital.

From the tables 1—4 appears more exactly the total number of cases of acute appendicitis and appendicitis with peritonitis treated in these hospitals during the period comprised in my

TABLE 1. Survey of cases of acute appendicitis and appendicitis with peritonitis from the different hospitals during the period comprised in the investigation.

Diagnosis	Number of cases	Number of operated cases	Number of drained cases	Number of deaths
Appendicitis acuta non perforata	11 947	8 283	97	171
Appendicitis acuta perforata et peritonitis diffusa incipiens ..	1 289	866	213	88
Appendicitis acuta perforata et peritonitis diffusa universalis	1 463	1 722	711	329
Abscessus periappendicularis ..	1 456	433	74	67
Total	16 155	11 304	1 095	655

Number of certain cases suitable for my investigation 2 482
 Number of posted questionnaires 1 752
 Number of cases included in the statistics 1 062

TABLE 2. Survey of cases of acute appendicitis and appendicitis with peritonitis of the Viipuri County Hospital during the years 1913—1932.

Diagnosis	Number of cases	Number of operated cases	Number of drained cases	Number of deaths
Appendicitis acuta non perforata	4 145	3 229	23	61
Appendicitis acuta perforata et peritonitis diffusa incipiens ..	397	397	146	17
Appendicitis acuta perforata et peritonitis diffusa universalis	343	835	268	122
Abscessus periappendicularis ..	562	130	45	21
Total	6 047	4 591	482	221

Number of certain cases suitable for my investigation 1 237
 Number of posted questionnaires 832
 Number of cases included in the statistics 576

TABLE 3. Survey of cases of acute appendicitis and appendicitis with peritonitis of the I and II Surgical Clinic of the University of Helsinki during the years 1915—1932.

Diagnosis	Number of cases	Number of operated cases	Number of drained cases	Number of deaths
Appendicitis acuta non perforata	3 059	2 154	6	64
Appendicitis acuta perforata et peritonitis diffusa incipiens ..	667	260	38	58
Appendicitis acuta perforata et peritonitis diffusa universalis	595	454	244	113
Abscessus periappendicularis ..	505	170	19	33
Total	4 826	3 038	307	268

Number of certain cases suitable for my investigation 452
 Number of posted questionnaires 129
 Number of cases included in the statistics 185

TABLE 4. Survey of cases of acute appendicitis and appendicitis with peritonitis of the Maria City Hospital during the years 1905—1932.

Diagnosis	Number of cases	Number of operated cases	Number of drained cases	Number of deaths
Appendicitis acuta non perforata	4 743	3 505	68	46
Appendicitis acuta perforata et peritonitis diffusa incipiens ..	225	209	29	13
Appendicitis acuta perforata et peritonitis diffusa universalis	525	433	199	94
Abscessus periappendicularis ..	389	133	10	13
Total	5 882	4 280	306	166

Number of certain cases suitable for my investigation 793
 Number of posted questionnaires 497
 Number of cases included in the statistics 301

investigation. I have also stated in connection with each table the number of cases obtained on the basis of the records and suitable for my investigation, and the number of posted inquiries as well as the number of cases comprised in the final statistics. The group of operated cases includes all cases in which appendectomy, or — in cases of periappendicular abscesses — incision has been performed.

The group of drained cases on the other hand includes all cases in which, according also to the annual report, both appendectomy and drainage of the abdominal cavity or the abscess was undoubtedly performed.

I have based these tables on the annual reports of the hospitals in question. Far from always does it appear from the annual reports, or the register of patients of the hospital if, for instance, drainage of the abdominal cavity has been performed in connection with the appendectomy or, when appendectomy has been performed, in connection with incision and drainage of an abscess. As appears from table 1 only 1 095 certain cases, based on the annual report, can be used in my investigation although their number when based on records and operation reports is considerably higher. This appears, for instance, from the fact that after careful examination of the records and operation reports of all patients in the different hospitals on whom appendectomy had been performed in the acute stage, and who had been discharged as convalescents — thus about 11 000 — only a total of 2 482 cases contained all information necessary for my investigation.

In order to ascertain the result of the operation I sent the patients printed questionnaires requesting them to reply to the questions and to return the inquiry free from postage. I was authorized to send the questionnaires in the name of the chiefs of the respective hospitals, for which I am very grateful, as a greater number of replies could thus be expected.

The contents of the questionnaires was as follows:

Name:

Age:

Occupation:

On account of your appendix having been removed in
at the Hospital, I beg you kindly to answer the
following questions to elucidate the final result of the operation.

(If the person in question is dead, I would ask his relatives kindly to
reply to the most important questions, and to state the date and the cause
of his death.)

When did the operative wound heal after discharge from the hospital?

Did it suppurate?

Have you done heavy work after the removal of the appendix?

How soon after the operation did you resume normal work?

Did a rupture develop in the operative scar?

How soon did it appear after the operation?
 Can you mention any reason for it?
 Has a renewed operation been performed? When and in which hospital?
 Was the scar firm after the second operation? (This question should be
 answered only in case a second operation has been made)
 Did a right inguinal hernia, or a rupture of the right groin occur after the
 operation of the appendix?
 How did the intestine function after the occurrence of the rupture?
 Do you have rumbling in the bowels?
 Do you have flatulence?
 Do you have sudden diarrhea?
 Have you suffered from a burning pain in the stomach after the operation?
 Or from attacks of pain?
 How long did the attack last?
 Did you vomit?
 What kind of vomit: Did it consist of food, or was it bilious, evil-smelling,
 feculent?
 Do you have rumbling in the stomach?
 Did air escape from the anus during the attack of pain?
 Did the bowels move? What kind of motions? (hard, ordinary, loose)
 Did you have to call a physician and what did he say?
 Was it a beginning attack of ileus?
 Did the attack pass of itself, after enema, or was operation performed?
 In which hospital were you operated and when?
 Was there just one, or several attacks?
 When was the last attack?
 Did some kind of rupture or coil of intestine protrude from the scar during
 the attack?
 Notes:

Yours very truly,

Chief of the Hospital.

The number of replies which I could use, was as follows:

The Viipuri County Hospital	576
The Surgical Clinic	185
The Maria City Hospital	301

Total number of cases 1 062

From table 5 appear the cases contained in my investigation divided according to different years and different hospitals separately and all together.

Having collected my material I entered all the necessary information on cards, and with the aid of the obtained statistics I have as far as possible tried to elucidate the question of incisional and inguinal herniae as well as of mechanical intestinal disturbances within the range of an investigation this nature.

TABLE 5.

Year	The Viipuri County Hospital	The I & II Surgical Clinic	The Maria City Hospital	Total
1906	—	—	2	2
1907	—	—	4	4
1908	—	—	3	3
1909	—	—	5	5
1910	—	—	5	5
1911	—	—	7	7
1912	—	—	7	7
1913	—	—	3	3
1914	1	—	11	12
1915	14	5	10	29
1916	10	3	17	30
1917	4	4	12	20
1918	12	1	7	20
1919	23	6	15	44
1920	21	7	8	36
1921	14	4	6	24
1922	15	13	7	35
1923	20	12	15	47
1924	25	13	24	62
1925	52	16	13	81
1926	55	16	14	85
1927	34	8	9	51
1928	54	11	17	82
1929	40	17	9	75
1930	38	11	19	68
1931	71	19	25	115
1932	64	19	27	110
Total	576	185	301	1 062

The information obtained from the records was as follows:

- 1) diagnosis,
- 2) sex,
- 3) age,
- 4) occupation,
- 5) how soon operated after having fallen ill,
- 6) the nature of the incision,
- 7) was the appendix removed in connection with the operation,
- 8) time of drainage and kind of drain used (rubber tube, cigaret drain, DREESMANN's glass tube),
- 9) certainty as to the closure of the wound to the drain.

The statistics comprise only such drained cases in which the wound was closed to the drain and for the drainage of which either a rubber tube, a cigaret drain or a DREESMANN glass tube was used. The thickness of the drain is hardly ever stated in the records, neither whether the drain was inserted into the area of the removed appendix, or into the true pelvis, or into both these areas.

In all cases of periappendicular abscess comprised in the material, the appendix was removed in connection with laparotomy.

It was not possible to ascertain whether the abdominal layers were closed with catgut or silk as the records were generally very incomplete in this respect. It was even sometimes impossible to ascertain in how many layers the closure was performed and whether a continuous or an interrupted suture was used. One thing is, however, certain in my cases, viz. that the abdominal layers were closed to the drain.

In the operation reports some surgeons have by the term pararectus incision referred to LENNANDER's and some to KROGIUS's incision. In order to ascertain which incision had been used I sent a letter of inquiry to the colleagues in question or turned to the chiefs of the respective hospitals for assistance.

Neither could I determine the length of the incision with the aid of the records.

Washing of the peritoneal cavity in connection with appendicitis with peritonitis was during the period comprised by my material, for the most part performed only at the Viipuri County Hospital, and to some extent also at the Maria City Hospital.

Description of the Appendectomy Incisions and Diagnoses Comprised in my Material.

The muscle-splitting incision refers to the original MCBURNEY incision, KROGIUS's incision to the longitudinal incision already described which does not involve the rectus sheath and which is performed in the area of the aponeuroses, and LENNANDER's incision to a lateral pararectus incision.

The grouping of my material according to diagnoses was spontaneously determined on the basis of the denominations used in our hospitals for peritoneal inflammations following appendicitis. The diagnoses of the records are generally based on clinical symptoms, on results of objective examinations and on observations made in connection with the operation.

Diagnosis I: *Appendicitis acuta non perforata* refers to cases in which the appendix is inflamed but in which no inflammatory symptoms can be found in the peritoneum except a clear or turbid odourless fluid in the peritoneal cavity. Neither does the general condition in any way indicate peritonitis. Although these cases are not cases of appendicitis with peritonitis, I have included them in my investigation because drainage of the abdominal cavity was administered owing to early exudate. According to literature these cases have earlier often been regarded as cases of beginning diffuse peritonitis due to the exudation which was undefined as to its bacteria and which should be regarded as a collateral edema.

II. In cases of *appendicitis acuta perforata et peritonitis diffusa incipiens* the appendix is perforated, there is ill-smelling pus around it and the general condition as well as the results of objective examinations and observations in connection with the operation indicate beginning peritonitis. This group is actually a sub-group of the following, that of general diffuse peritonitis, but because of the slight symptoms and minor pathological anatomical changes it has been grouped separately. Peritonitis incipiens and peritonitis progrediens seem to have been quite common diagnoses here about 1910. They are probably based on the fact that after perforation of the appendix the surrounding peritoneum first becomes inflamed, the infection gradually spreading to a larger area in some cases rapidly, in others slowly depending on the virulence of the infection and on the reaction of the peritoneum. (In Germany in the beginning

of the 20th century the term peritonitis progrediens referred to a beginning diffuse general peritonitis). Some authors consider it quite unnecessary to divide different stages of the same disease into separate groups. This is, for instance, G. BAUER's opinion.

III: In cases belonging to the group *appendicitis acuta perforata et peritonitis diffusa universalis* the appendix is perforated and the patients show symptoms of a serious, far developed peritonitis. A large quantity of free pus has been found in the abdominal cavity in connection with the operation.

IV. In cases of *abscessus periappendicularis* a limited inflammatory focus occurred in the region of the appendix.

Presentation of the Problem.

After I entered the material from the Viipuri County Hospital on my cards, the hospital and its records were consumed by fire. Therefore I was not able to obtain further casuistic information for my work and, for the sake of conformity, I refrained from obtaining such information also with regard to the Surgical Clinic of the University of Helsinki and the Maria City Hospital trying, however, to get as much as possible out of my material within these limits. With regard to incisional herniae I have principally investigated the following 6 questions:

1) What is the relation of age and sex to the occurrence of incisional herniae and what is the relation between the frequencies of incisional herniae following the use of MCBURNEY'S, LENNANDER'S and KROGIUS'S incision?

2) How does the occupation influence the occurrence of incisional herniae?

3) Does the circumstance on which day after the onset of the disease operation has been performed, in any way influence the frequency of incisional herniae, and what is the relation of the different incisions to one another in this respect?

4) Does the circumstance at what stage of the disease operation is performed in any way influence the frequency of incisional herniae and are there differences in this respect which depend on the incision?

5) *How does the duration of drainage influence the occurrence of incisional herniae?*

6) *How often were renewed operations because of incisional herniae necessary?*

I have determined the statistical probability of the results with the aid of RITALA's (1934) tables of probabilities. For the sake of conformity I have in all cases performed a comparison with the mean value of the corresponding statistics. When there are two values only the result is somewhat less favourable than the probable; when the mean value is derived from several values the result may be somewhat more favourable than the probable. The difference is, however, small enough not to necessitate more complicated procedures in these statistics.

In my statistical conclusions I have used the following expressions: If the percentage of the sub-group to be compared deviates from the percentage of the entire statistics

about	1.5	times	the	mean	error	ε	(p):	possible
»	2	»	»	»	»	»	»	: very possible
»	2.5	»	»	»	»	»	»	: almost certain
at least	3	»	»	»	»	»	»	: certain

The Relation of Age and Sex to Predisposition to Incisional Herniae Following Different Appendectomy Incisions.

1. Predisposition to incisional herniae in general at different ages.

When looking at table 6 showing the distribution of incisional herniae on the various age groups of the total material, we shall find the herniae rather diffusedly distributed according to the various age groups. There is no distinct regularity, a fact which might depend on the circumstance that my material (1 062 cases) which is rather small for this kind of investigation, had to be divided in so many parts. I have therefore grouped the patients in age groups of ten years so that the young (1—30 years), the middle-aged (31—50 years) and the old (51 years and older) would each form an entirety of their own. It will thus clearly appear how the frequency of herniation increases with increasing age. 12.7 per

TABLE 6. Predisposition to herniation at different ages.

Age	Number of operations	Number of incisional herniae	Percentage of incisional herniae	Percentage of mean error ε (p)
1—10	58	11	19.0	± 4.1
11—20	203	17	8.4	± 2.2
21—30	299	43	14.4	± 1.8
31—40	233	37	15.8	± 2.1
41—50	141	21	14.8	± 2.7
51—60	83	11	13.3	± 2.5
61—70	38	9	23.7	± 5.2
71—	7	1	14.3	± 14.0
Total	1 062	150	14.1	± 1.1

cent of the patients between 1—31 years have developed herniae after drained appendectomies, 15.5 per cent between 31—50 years and 16.4 per cent of 51 years and older.

My classification of the groups «young», «middle-aged» and «old» is not haphazard, but is based on results of careful physiological investigations. UFLAND established in 1933 in his muscle-physiological experiments at the Laboratory of Occupational diseases of Leningrad that the muscle power increases with age reaching a maximum at the age of 30 years, whereafter it begins to decrease. It should further be mentioned that the changes in muscle power depending on age, is not to any noticeable degree influenced by the occupation or by the constitution. COWDRY in 1942 also established that the firmness and power of the muscles reach a maximum about the 30th year, the mass and roentgenographic denseness however increasing until the 50th year. COWDRY also points out that neither the aponeuroses nor the tendons or the ligaments show any distinct changes caused by age.

On the basis of the mentioned experiments by UFLAND and COWDRY I consider myself justified in choosing the 30th and the 50th year of life as a limit in judging the firmness of the abdominal wall in the light of herniation percentages.

As the muscles reach their maximum power in the 30th year, young persons, on account of the strength of the muscles of the abdominal wall, have a bigger chance of fighting the danger of herniation than persons over 30 years, and particularly those who

have already reached 51. On the other hand the low percentage of herniae in comparison with the older age groups, due to the greater muscular power in youth is, because of the hard life of the young, not so evident. The percentage of herniae in this group is also increased by the comparatively high frequency of herniae (19 per cent) in children (1—10 years) which is partly due to the fact that these were mostly cases of serious appendicitis with peritonitis and partly that at this age the peritoneum and the abdominal layers are still so thin that even a slight increase in the intra-abdominal pressure may cause separation of the laparotomy wound or a rupture beside the suture. On the other hand the increase of the total percentage caused by the high percentage of herniae in children between 1 and 10 years, is reduced by the lowest percentage of the entire statistics, viz. that of patients between 11—20 years. At this age the general vitality and power of resistance is great which certainly also acts upon the power of resistance of the various tissues. It is a common experience that, for instance, wounds heal extremely well in patients between 11—20 years, a fact which may account for the low frequency of incisional herniae in laparotomy wounds in this age group.

So far I have related the distribution of incisional herniae on the different age groups by means of simple percentages. If, however, the mean error percentage $\epsilon(p)$ is calculated for each group, and the dependance of the predisposition for incisional herniae on the age is determined from this, the results are entirely different. Table 6 shows also the mean error of the incisional herniae percentage in all age groups. If we compare the percentages of all the three principal age groups with the hernia percentage of the total statistics we shall find that they all vary within the limits of the mean error, viz. that they deviate from it by one mean error at the most. Therefore *it cannot be statistically determined whether the percentage of incisional herniae is dependent on age*. This appears from the following expressions:

$$\begin{array}{ll}
 1-30 \text{ years} & 12.7 - 14.1 = -1.4 \pm 1.3 \quad (1.1 \times 1.3 = 1.4) \\
 31-50 \quad \gg & 15.5 - 14.1 = +1.4 \pm 1.6 \quad (0.8 \times 1.6 = 1.3) \\
 51 \quad \gg & 16.4 - 14.1 = +2.3 \pm 2.8 \quad (0.8 \times 2.8 = 2.2) \\
 \text{and older} &
 \end{array}$$

But even though the said percentages deviate within limits

larger than those of the mean error the conclusion would be of no value as the conformity to law by both women and men is, according to the later tables (7 and 8) quite different.

A statistically very important sub-group is that of the patients aged 11—20. In this group the deviation from the mean value is 5.7 per cent, viz. 2.6 times the mean error (± 2.2 per cent): $8.4 - 14.1 = -5.7 \pm 2.2$ ($2.6 \times 2.2 = 5.7$). The low percentage of herniae must therefore actually be considered a characteristic of the group.

We arrive at the same result if we examine the group of patients between 1—20 years separately according to the different incisions (tables 9—17) with the exception of one small sub-group (table 14).

2. Predisposition to incisional herniae in men at different ages.

TABLE 7. Predisposition to incisional herniae in men at different ages.

Age	Number of operations	Number of incisional herniae	Percentage of incisional herniae	Percentage of mean error ϵ (p)
1—10	31	5	16.1	± 5.6
11—20	109 } 332	7 } 33	6.4 } 9.9	± 2.9 } ± 1.7
21—30	192	21	10.1	± 2.2
31—40	159 } 257	23 } 34	14.5 } 13.2	± 2.5 } ± 1.9
41—50	98	11	11.2	± 3.1
51—60	54	4	7.4	± 4.2
61—70	25 } 84	3 } 7	12.0 } 8.3	± 6.2 } ± 3.4
71—	5	—	—	± 14.0
Total	673	74	11.0	± 1.2

On examining table 7 we shall make the same observation as with regard to table 6 viz. that the distribution of incisional herniae on the different age groups is very irregular. (Children between 1—10 years have seemingly the highest percentage of herniae). If we treat the cases of this table in larger groups: «youth», «middle-age» and «old-age», the apparent difference between the first and second group is 3.3 per cent. The hernia percentage in men older than 51 years is obviously lower than in other groups, which might be attributed to the fact that they take care of their health better than the young, allowing themselves a sufficiently long period of convalescence after the operation and avoiding too heavy bodily strain.

If, however, we study our examination in the light of the statistics and, with attention paid to the mean errors, determine the distribution of herniae in men of different age groups, the separate classes vary within the limits of the mean error, the age group 11—20 years excepted. In the same way the hernia percentage of the three sub-groups also vary within the limits of the mean error:

$$\begin{array}{lll}
 1-30 \text{ years} & 9.9 - 11.0 = -1.1 \pm 1.7 & (0.6 \times 1.7 = 1.0) \\
 31-50 & \gg & 13.2 - 11.0 = +2.2 \pm 1.9 \quad (1.2 \times 1.9 = 2.2) \\
 51 & \gg & 8.3 - 11.0 = -2.7 \pm 3.4 \quad (0.8 \times 3.4 = 2.7) \\
 & \text{and older} &
 \end{array}$$

Neither can it thus be established with statistical certainty whether the occurrence of incisional herniae in men is dependent on age.

We arrive at the same result when examining the distribution of incisional herniae in men separately according to each incision and according to LENNÄNDER's and KROGIUS's incisions together, both for the large and the small age groups (tables 10, 13, 16 and 19). When the comparatively small total number of cases is divided into so many groups as in the mentioned tables, the number of cases referred to each sub-group is so small that no definite conclusions can be drawn.

3. Predisposition to incisional herniae in women at different ages.

It appears from table 8 that the percentage of herniae in women is generally extremely high and it seems to increase fairly regularly

TABLE 8. Predisposition to incisional herniae in women at different ages.

Age	Number of operations	Number of incisional herniae	Percentage of incisional herniae	Percentage of mean error ε (p)
1—10	27	6	22.2	± 7.6
11—20	94	10	10.6	± 4.1
21—30	107	22	20.7	± 3.8
31—40	74	14	18.9	± 4.6
41—50	43	10	23.2	± 6.0
51—60	29	7	29.1	± 7.4
61—70	13	6	46.1	± 11.0
71—	2	1	50.0	± 27.0
Total	389	76	19.6	± 1.8

each decennium with increasing age with the exception of the high percentage of herniae in children (1—10 years). The apparent differences in the hernia percentages of young, middle-aged and old women are great.

The great frequency of herniae in women is probably due to several factors. Stretching of a scar during pregnancy in women of the childbearing age is an important factor in the occurrence of herniae, particularly if the operation was performed shortly before conception or during pregnancy. The abdominal layers stretched and slackened through pregnancy, do not even later give support comparable to that of the abdominal muscles of men, hardened by work.

In the same way the postclimacteric obesity which frequently occurs, may cause fat to enter between the sutures in operations thereby forming a base for herniation. Both the abdominal muscles and the peritoneum become weaker through obesity. Another reason for the large increase in the hernia percentage of women besides the changes brought on by the climacterium, may be their position in the home. After an operation the average house-wife must resume her work much sooner than a man as the care of the house suffers greatly through the illness of the wife.

Examining statistically also the hernia percentages in women we shall find that they too vary within the limits of the mean error. The matter is, however, different when we compare the groups of »young», »middle-aged» and »old» women with one another. The deviation of the mean error percentage of these three sub-groups from the mean error percentage of the whole statistics appears from the following expressions:

$$\begin{array}{lcl}
 1-30 \text{ years} & 16.7 - 19.6 = - 2.9 \pm 2.6 & (1.1 \times 2.6 = 2.9) \\
 31-50 \quad \text{»} & 20.5 - 19.6 = + 0.9 \pm 3.7 & (0.3 \times 3.7 = 1.1) \\
 51 \quad \text{»} & 31.8 - 19.6 = +12.2 \pm 6.0 & (2.0 \times 6.0 = 12.0) \\
 \text{and older} & &
 \end{array}$$

On the basis of this result we may with a fair amount of certainty state that *the predisposition to herniae in women increases with age.*

When examining tables 11, 14 and 17 from which appears the predisposition to incisional herniae in women in connection with the different incisions, we again find the material too small to allow any definite conclusions. If, however, tables 14 and 17,

TABLE 9. Predisposition to incisional herniae after McBURNEY's incision.

Age	Number of operations	Number of incisional herniae	Percentage of incisional herniae	Percentage of mean error ϵ (p)
1—10	23	4	17.4	7.2
11—20	75	3	4.0	
21—30	109	8	7.3	
31—40	60	6	10.0	8.7
41—50	43	3	6.9	
51—60	24	2	8.3	
61—70	11	2	18.1	10.5
71—	3	—	—	
Total	348	28	8.0	1.4

TABLE 10. Predisposition of men to incisional herniae after McBURNEY's incision.

Age	Number of operations	Number of incisional herniae	Percentage of incisional herniae	Percentage of mean error ϵ (p)
1—10	9	2	22.2	8.3
11—20	37	3	8.1	
21—30	62	4	6.4	
31—40	41	4	9.8	7.1
41—50	29	1	3.4	
51—60	16	1	6.3	4.0
61—70	7	—	—	
71—	2	—	—	
Total	203	15	7.4	

TABLE 11. Predisposition of women to incisional herniae after McBURNEY's incision.

Age	Number of operations	Number of incisional herniae	Percentage of incisional herniae	Percentage of mean error ϵ (p)
1—10	14	2	14.3	6.0
11—20	38	—	—	
21—30	47	4	8.5	
31—40	19	2	10.5	12.1
41—50	14	2	14.3	
51—60	8	1	12.5	23.7
61—70	4	2	50.0	
71—	1	—	—	
Total	145	13	9.0	

TABLE 12. Predisposition to incisional herniae after LENNANDER's incision.

Age	Number of operations	Number of incisional herniae	Percentage of incisional herniae	Percentage of mean error ε (p)
1—10	5	2	40.0	21.3 14.3 18.4
11—20	28	7	25.0	
21—30	103	20	19.4	
31—40	121	18	14.9	
41—50	68	9	13.2	
51—60	48	7	14.6	
61—70	24	6	25.0	
71—	4	1	25.0	
Total	401	70	17.5	± 1.9

TABLE 13. Predisposition of men to incisional herniae after LENNANDER's incision.

Age	Number of operations	Number of incisional herniae	Percentage of incisional herniae	Percentage of mean error ε (p)
1—10	2	2	100.0	14.1 12.1 9.8
11—20	12	1	8.3	
21—30	71	9	12.7	
31—40	75	11	14.7	
41—50	49	4	8.1	
51—60	30	2	6.7	
61—70	18	3	16.7	
71—	3	—	—	
Total	260	32	12.3	

TABLE 14. Predisposition of women to incisional herniae after LENNANDER's incision.

Age	Number of operations	Number of incisional herniae	Percentage of incisional herniae	Percentage of mean error ε (p)
1—10	3	—	—	33.3 18.5 36.0
11—20	16	6	37.5	
21—30	32	11	34.4	
31—40	46	7	15.2	
41—50	19	5	26.3	
51—60	18	5	27.8	
61—70	6	3	50.0	
71—	1	1	100.0	
Total	141	38	26.9	

TABLE 15. Predisposition to incisional herniae after KROGIUS's incision.

Age	Number of operations	Number of incisional herniae	Percentage of incisional herniae	Percentage of mean error ε (p)
1—10	30	6	20.0	
11—20	100	7	7.0	
21—30	87	14	16.1	
31—40	52	13	25.0	
41—50	30	9	30.0	
51—60	11	2	18.1	
61—70	3	1	33.3	
71—	—	—	—	
Total	313	52	16.3	± 2.1

TABLE 16. Predisposition of men to incisional herniae after KROGIUS's incision.

Age	Number of operations	Number of incisional herniae	Percentage of incisional herniae	Percentage of mean error ε (p)
1—10	20	2	10.0	
11—20	60	3	5.0	
21—30	59	8	13.7	
31—40	43	8	18.6	
41—50	20	5	25.0	
51—60	8	1	12.5	
61—70	—	—	—	
71—	—	—	—	
Total	210	27	12.9	

TABLE 17. Predisposition of women to incisional herniae after KROGIUS's incision.

Age	Number of operations	Number of incisional herniae	Percentage of incisional herniae	Percentage of mean error ε (p)
1—10	10	4	40.0	
11—20	40	4	10.0	
21—30	28	6	21.4	
31—40	9	5	55.6	
41—50	10	4	40.0	
51—60	3	1	33.3	
61—70	3	1	33.3	
71—	—	—	—	
Total	103	25	24.3	

TABLE 18. Predisposition to incisional herniae after LENNANDER's and KROGIUS's incision.

Age	Number of operations	Number of incisional herniae	Percentage of incisional herniae	Percentage of mean error ε (p)
1—10	35	8	22.8	$\left. \begin{array}{l} 15.9 \\ 18.1 \\ 18.9 \end{array} \right\}$
11—20	128	14	10.9	
21—30	190	34	17.9	
31—40	173	31	17.9	
41—50	98	18	18.4	
51—60	59	9	15.3	
61—70	27	7	25.9	
71—	4	1	25.0	
Total	714	122	17.1	± 1.5

TABLE 19. Predisposition of men to incisional herniae after LENNANDER's and KROGIUS's incision.

Age	Number of operations	Number of incisional herniae	Percentage of incisional herniae	Percentage of mean error ε (p)
1—10	22	4	18.0	$\left. \begin{array}{l} \pm 7.0 \\ \pm 3.9 \\ \pm 2.9 \\ \pm 3.2 \\ \pm 4.0 \\ \pm 5.4 \\ \pm 7.8 \\ \pm 19.0 \end{array} \right\} \pm 2.2$
11—20	72	4	5.6	
21—30	130	17	13.1	
31—40	108	19	17.6	
41—50	69	9	13.0	
51—60	38	3	7.9	
61—70	18	3	16.7	
71—	3	—	—	
Total	470	59	12.5	± 1.9

TABLE 20. Predisposition of women to incisional herniae after LENNANDER's and KROGIUS's incision.

Age	Number of operations	Number of incisional herniae	Percentage of incisional herniae	Percentage of mean error ε (p)
1—10	13	4	30.8	$\left. \begin{array}{l} \pm 12.0 \\ \pm 5.7 \\ \pm 5.6 \\ \pm 5.8 \\ \pm 8.0 \\ \pm 9.3 \\ \pm 14.0 \\ \pm 43.0 \end{array} \right\} \pm 7.7$
11—20	56	10	17.8	
21—30	60	17	28.4	
31—40	55	12	21.8	
41—50	29	9	31.0	
51—60	21	6	28.6	
61—70	9	4	44.5	
71—	1	1	100.0	
Total	244	63	24.7	± 2.4

(LENNANDER's and KROGIUS's incisions) which are almost analogous, are treated as one, the matter will be more favourable. We will then find an evident increase with age in the percentage of incisional herniae.

4. *Relation of the predisposition to incisional herniae of men and women to one another.*

If we compare the percentages of the whole statistics for men and women (tables 7 and 8) we find that the frequency of incisional herniae is about twice as large (19.6 per cent) in women as in men (11.0 per cent). This relation holds good also statistically:

$$\begin{array}{ll} \text{Men} & \dots \quad 11.0 - 14.1 = -3.1 \pm 1.2 \quad (2.5 \times 1.2 = 3.0) \\ \text{Women} & \dots \quad 19.6 - 14.1 = +5.5 \pm 1.8 \quad (3.1 \times 1.8 = 5.5) \end{array}$$

It can therefore be considered statistically proved that *the strong predisposition to incisional herniae in women is a quality of sex and that this quality is considerably stronger in women than in men.*

5. *Relation to one another of the predisposition to incisional herniae in men and women in cases operated upon through different incisions.*

As appears in the foregoing there is a considerable difference between the predisposition to incisional herniae in men and women in the statistics which include all cases of my material.

If we examine the difference in the predisposition to incisional herniae in men and women separately in cases operated on through different incisions we make the following observation:

Sex	Number of operations	Percentage of incisional herniae	Percentage of mean error ε (p)
Men	203	7.4	± 0.8
Women ..	145	9.0	± 1.0
Total	348	8.0	± 1.4

When MCBURNEY's incision has been used the difference between the percentage of incisional herniae in men and women is extremely small, yet the mean values show that incisional herniae occur more

frequently in women than in men although it cannot be considered statistically certain, the mean error percentages covering the difference in the hernia percentage of men and women.

In cases of LENNANDER's incision the difference between the hernia percentages in men and women is considerable. The percentage of incisional herniae in women is twice as large as that of men:

Sex	Number of operations	Percentage of incisional herniae	Percentage of mean error ε (p)
Men	260	12.3	± 0.9
Women ..	141	26.9	± 1.2
Total	401	17.5	± 1.9

It is also statistically certain that women develop more incisional herniae than men after LENNANDER's incision:

$$\text{Men} \quad \dots \quad 12.3 - 17.5 = -5.2 \pm 0.9 \quad (5.8 \times 0.9 = 5.2)$$

$$\text{Women} \quad \dots \quad 26.9 - 17.5 = +9.4 \pm 1.2 \quad (7.8 \times 1.2 = 9.4)$$

After KROGIUS's incision the difference in the predisposition to incisional herniae in men and women is also great, being almost double. It appears from table 16 and 17 that the hernia percentage in women is 24.3 and in men 12.9.

Sex	Number of operations	Percentage of incisional herniae	Percentage of mean error ε (p)
Men	210	12.9	± 1.0
Women ..	103	24.3	± 1.4
Total	313	16.3	± 2.1

The difference in the predisposition to hernia in men and women is also statistically certain:

$$\text{Men} \quad \dots \quad 12.9 - 16.3 = -3.4 \pm 1.0 \quad (3.4 \times 1.0 = 3.4)$$

$$\text{Women} \quad \dots \quad 24.3 - 16.3 = +8.0 \pm 1.4 \quad (5.7 \times 1.4 = 8.0)$$

When examining separately the differences between the predisposition to incisional herniae in men and women after different methods of operation, we obtain almost the same results for LENNAN-

DER's and KROGIUS's incisions (tables 13, 14, 16 and 17). I shall therefore deal with them together, determining the relation of the hernia percentages in men and women.

Sex	Number of operations	Percentage of incisional herniae	Percentage of mean error ε (p)
Men	470	12.5	± 1.9
Women ..	244	24.7	± 2.4
Total	714	17.1	± 1.5

As appears from the above table *women develop considerably more incisional herniae than men after the use of the mentioned incisions and this fact holds good also statistically:*

$$\text{Men} \quad \quad 12.5 - 17.1 = -4.6 \pm 1.9 \quad (2.4 \times 1.9 = 4.6)$$

$$\text{Women} \quad . . \quad 24.7 - 17.1 = +7.6 \pm 2.4 \quad (3.2 \times 2.4 = 7.6)$$

Tables 12 and 15 show that there is no noticeable difference with regard to incisional herniae in general between LENNANDER's and KROGIUS's incisions, a fact which is also statistically confirmed:

$$\text{LENNANDER's incision} \quad 17.5 - 14.1 = +3.4 \pm 1.9 \quad (1.8 \times 1.9 = 3.4)$$

$$\text{KROGIUS's incision} \quad 16.3 - 14.1 = +2.2 \pm 2.1 \quad (1.0 \times 2.1 = 2.1)$$

In the following I shall deal with incisional herniae following LENNANDER's and KROGIUS's incisions together (table 18) comparing the frequency with the hernia percentage of MCBURNEY's incision (table 9), on the basis of the percentage of the total statistics:

$$\left. \begin{array}{l} \text{LENNANDER's incision} \\ \text{KROGIUS's incision} \end{array} \right\} 17.1 - 14.1 = +3.0 \pm 1.5 \quad (2.0 \times 1.5 = 3.0)$$

$$\text{MCBURNEY's incision} \quad 8.0 - 14.1 = -6.1 \pm 1.4 \quad (4.5 \times 1.4 = 6.3)$$

The difference between the predisposition to incisional herniae of the mentioned incisions is quite certain in the respect that *there are considerably fewer cases of incisional herniae following MCBURNEY's incision than LENNANDER's and KROGIUS's incisions.*

To complete my information I shall in the following relate some results from literature with regard to the relation of percentages of incisional herniae in men and women. The values cannot, however, be compared with those obtained by myself as the statistics are by no means founded on a homogenous basis. AMBERGER's (1906), statistics, for instance, include 92 purulent appendectomies; drained and undrained cases are dealt with together and the kind of incision is not mentioned. The percentage of incisional herniae in men was 15.4 and in women 7.5. CARLUCCI (1934) arrives at about the same result, the percentage in men being 14.6 and that in women 7.5. His statistics were based both on cases of drained and undrained acute and chronic appendicitis operated through McBURNEY's incision or through the transrectus longitudinal incision through the right rectus muscle which incision is still much used in America. It should also be mentioned that CARLUCCI's period of observation with regard to the occurrence of incisional herniae was, at least in some cases, too short. He included in his statistics patients who had been discharged from the hospital only half a year when, according to general opinion among surgeons, the period of observation should be at least 2 years, according to some even 3 years. According to LINDENSTEIN (1909) a scar should not be considered final and secure until three years after an operation.

MASSON (1923), basing his opinion on the material of the Mayo Clinic, has established, that incisional herniae are more frequent in women than in men. His statistics are based on 596 cases operated for incisional hernia. In the cases included in the statistics many different appendectomy incisions had been employed and the statistics comprised incisional herniae following all laparotomies performed for different reasons.

6. *Relation to one another of incisional herniae in boys and girls.*

BEEKMAN (1924) i.a. has studied the occurrence of incisional herniae in children (1—13 years) after appendectomies. The period of observation ranged between $\frac{1}{2}$ and 3 years and the incisions employed were either a longitudinal incision of the rectus muscle or McBURNEY's incision. In these statistics which comprise only acute

cases, the drained and undrained cases are dealt with together. The material comprises after-examinations of a total of 126 patients. In drained cases 18 per cent incisional herniae occurred, there was herniation only in drained cases, and no differences in the frequency of herniae could be observed with regard to sex. The predisposition to herniation seemed to be greater in children.

The predisposition to incisional herniae in children of my material appears from the following table:

Sex	Number of operations	Number of incisional herniae	Percentage of incisional herniae	Percentage of mean error ϵ (p)
Boys	83	9	10.8	± 3.6
Girls	66	9	13.6	± 3.9
Total	149	18	12.1	± 2.7

In my statistics the percentage of incisional herniae in girls is higher (13.6 per cent) than in boys (10.8). If, however, the relation is statistically determined with attention paid to the mean error percentages which in this instance are large, *it cannot be established with certainty whether the sex of the patient is of any importance for the occurrence of incisional herniae in children:*

Boys $10.8 - 12.1 = -1.3 \pm 3.6$ ($0.4 \times 3.6 = 1.4$)

Girls $13.6 - 12.1 = +1.5 \pm 3.9$ ($0.4 \times 3.9 = 1.5$)

The Influence of Occupation on the Occurrence of Incisional Herniae.

It is generally considered that heavy bodily strain furthers the occurrence of incisional herniae. I have tried on the basis of my statistics to establish to what extent this statement is right. I have divided the patients of my material into labourers and intellectual workers, children of 1—15 years forming a group of their own. The following table was thus obtained (table 21):

In order to compare the relations of the predisposition to incisional herniae in labourers, intellectual workers and children to one another, we will obtain the following statistics (table 22) based on the above table:

TABLE 21.

Occupation	Men	Number of incisional herniae	Women	Number of incisional herniae
<i>Labourers</i>				
Ordinary workers	174	17	79	16
Agricultural labourers, fishermen ..	182	15	74	17
Factory workmen	34	5	4	—
Policemen, postmen, foremen	91	15	2	—
Craftsmen, maids, nurses	18	—	75	14
	499	52	234	47
<i>Intellectual workers</i>				
Students	12	2	3	1
Teachers, editors	10	—	14	3
Doctors, engineers	8	—	—	—
Business people, office employees ..	61	11	35	9
Married women	—	—	37	7
	91	13	89	20
<i>Children (1—15 years)</i>	83	9	66	9
Total number of cases	673	74	389	76

TABLE 22.

Occupation	Number of operations	Number of incisional herniae	Percent- age of incisional herniae	Percent- age of mean error ϵ (p)
Number of labourers	733	99	13.5	± 1.3
Number of intellectual workers ..	180	33	18.3	± 2.6
Number of children	149	18	12.1	± 2.8
Total	1 062	150	14.1	± 1.1

It must be observed, however, that an absolutely true picture of the difference in the relation of incisional herniae between labourers and intellectual workers cannot be obtained from the above. The labourers perform, as a rule, only manual labour, a great part of the intellectual workers, however, performing to a certain extent also manual work, or practising it voluntarily for instance in the form of sport. Therefore, the abdominal muscles of intellectual workers are not always untrained to an extent which

might be supposed from their occupation. As to the large frequency of incisional herniae in house-wives it should be remembered that it is impossible to judge from the records whether the title 'Mrs' refers to ladies in society or wives of workmen. Part of the married women certainly belong to the group labourers.

On examining table 22 we shall find that the hernia percentage in labourers (13.5) is considerably lower than in intellectual workers (18.3). The hernia percentage in children (12.1) is the lowest.

In order to establish the statistical certainty of these results we shall use the following expressions:

$$13.5 - 14.1 = -0.6 \pm 1.3 \quad (0.5 \times 1.3 = 0.6)$$

$$18.3 - 14.1 = +4.2 \pm 2.6 \quad (1.6 \times 2.6 = 4.2)$$

$$12.1 - 14.1 = -2.0 \pm 2.8 \quad (0.8 \times 2.6 = 2.1)$$

It seems thus as if intellectual workers would have a greater pre-disposition to incisional herniae than labourers, a fact which seems also statistically possible.

On the basis of the above results I feel inclined to draw the conclusion that *manual work in itself does not further the occurrence of incisional herniae, but if the abdominal muscles are untrained, as is generally the case with intellectual workers as compared with labourers, then bodily strain may possibly cause herniation.*

The Relation of the Period between the Onset of the Illness and the Operation to the Occurrence of Incisional Herniae.

1. *The relation of the period between the onset of the illness and the operation to the occurrence of incisional herniae in general.*

It is a well-known fact that in cases of acute appendicitis and appendicitis with peritonitis the length of the interval between the onset of the disease and the operation is of very great importance for the curing of the patient. Based on the mortality percentages in operations performed on the different days of illness, the appendectomies are divided into early, intermediary and late operations. Early operations give the best results and operations

are therefore performed as early as possible. 48 hours is generally considered the upper limit for an early operation, although there are those who limit the period to 24 hours (LÄWEN, 1939). As an example of how much the mortality percentages may vary in operations performed at the different stages mentioned, the statistics published by SPRENGEL in 1906 should be mentioned, according to which early operations give six times better results than those performed at later stages, and MARGOTTINI's material of 1938 according to which the mortality of patients operated at an early stage was 0.13 per cent and of those operated at later stages 8.6 per cent. Also HJELMMAN's (1932) investigations showed a similar increase in the mortality (0.88—5.26 per cent). In RENKONEN's (1946) material the mortality of peritonitis diffusa patients was 13.7 per cent if they came under treatment within three days, whereas it was 24.6 per cent of patients who were treated after the third day. In cases of periappendicular abscess the mortality was 3.8 and 4.8 per cent respectively.

In this connection the revolutionary practice originating in America should be mentioned according to which operation is performed only at an early stage when there are no symptoms of peritonitis; otherwise a conservative treatment is employed. Supporters of this line are i.a. the American surgeons JUNGBLUTH (1941, 1942), NAHRAHT (1941), BARROW & OCHSNER (1941) and the German surgeon RESCHKE (1926) — JACKSON & PERKINS in 1941 consider that due to the result of this line a total of 170 000 patients died of appendicitis with peritonitis in America during the period of 1928—1939.

Proceeding thus from the fact that, to save the life of the patient, it is of extreme importance on which day after the onset of the illness the operation for acute appendicitis or for appendicitis with peritonitis is performed, I wished, on the basis of my material, to investigate whether this circumstance in any way influences tissue regeneration, viz. do the local tissue changes resulting from a more advanced disease, possibly impede the healing of the wound if the operation is delayed. It should be noticed, however, that the clinical symptoms do not always correspond to the pathological-anatomical changes of the appendix and the peritoneum (PETERMANN, 1941) but there are cases in which the appendicitis leads to perforation

within 24 hours and even earlier, whereas in other cases more than three days may elapse before perforation occurs (BAUER). Therefore, the same stage of the disease does not always correspond to the stated day of illness. Because of this I have separately dealt with the question of the relation of incisional herniae to the day of operation and the stage of development. The results of the investigation of the former question are with certainty unfavourably influenced by the fact that the time given by the patients for the onset of the disease cannot always be relied upon.

I have in literature found no statistics showing the frequency of incisional herniae following operations performed on the different days of illness. Table 23 shows the distribution of my total material of incisional herniae with regard to the day of operation. We shall find that, *with small exceptions the tendency to incisional herniae increases with the length of the interval between the onset of the illness and the operation.*

If all cases operated within the first 48 hours are considered as operations at an early stage, we shall find that incisional herniae occur in 12.9 per cent of these cases, whereas herniation occurs in 18.9

TABLE 23. The relation of the interval between the onset of the disease and the operation to the occurrence of incisional herniae.

Operated not later than	Number of operations	Number of incisional herniae	Percentage of incisional herniae	Percentage of mean error ϵ (p)
24 hours after the first symptoms ..	282	34	12.0	± 2.1
48 " " " " " ..	395	53	13.4	± 1.7
72 " " " " " ..	175	20	11.4	± 2.6
more than 72 hours after the first symptoms	210	43	20.5	± 2.4
Total	1 062	150	14.1	± 1.1

per cent of cases operated later. It is also statistically almost certain that, when the patient arrives for operation at the earliest on the third day of the illness, the predisposition to incisional hernia is astonishingly great in comparison with cases treated by early

operation. *The predisposition to incisional hernia depends therefore almost certainly on the time of the operation:*

$$12.9 - 14.1 = -1.2 \pm 1.3 \quad (0.9 \times 1.3 = 1.2)$$

$$18.9 - 14.1 = +4.8 \pm 1.8 \quad (2.7 \times 1.8 = 4.9)$$

2. *The relation of the interval between the onset of the disease and the operation to the occurrence of incisional herniae in cases of different incisions.*

On examining separately the cases operated through different incisions (tables 24-26) we notice that the frequency of incisional

TABLE 24. The relation of the interval between the onset of the disease and the operation to the occurrence of incisional herniae in cases operated through MCBURNEY's incision.

Operated not later than	Number of operations	Number of incisional herniae	Percentage of incisional herniae	Percentage of mean error ε (p)
24 hours after the first symptoms..	97	8	8.2	± 2.7
48 " " " " " "	139	10	7.2	± 2.3
72 " " " " " "	51	1	2.0	± 3.8
more than 72 hours after the first symptoms	61	9	14.8	± 3.5
Total	348	28	8.0	± 1.4

TABLE 25. The relation of the interval between the onset of the disease and the operation to the occurrence of incisional herniae in cases operated through LENNANDER's incision.

Operated not later than	Number of operations	Number of incisional herniae	Percentage of incisional herniae	Percentage of mean error ε (p)
24 hours after the first symptoms..	100	14	14.0	± 3.8
48 " " " " " "	147	26	17.7	± 3.1
72 " " " " " "	74	12	16.2	± 1.3
more than 72 hours after the first symptoms	80	18	22.5	± 4.3
Total	401	70	17.5	± 1.9

TABLE 26. The relation of the interval between the onset of the disease and the operation to the occurrence of incisional herniae in cases operated through KROGIUS's incision.

Operated not later than	Number of operations	Number of incisional herniae	Percentage of incisional herniae	Percentage of mean error ε (p)
24 hours after the first symptoms ..	85	12	14.1	± 4.1
48 " " " " " " ..	109	17	15.6	± 3.5
72 " " " " " " ..	50	7	14.0	± 5.2
more than 72 hours after the first symptoms	69	16	23.2	± 4.4
Total	313	52	16.3	± 2.1

herniae following early operations is lower in all tables than after operations performed later. The largest difference in this respect (4.4 per cent) is found in cases operated through KROGIUS's incision (table 26). When LENNANDER's incision was used (table 25) the difference between the early and later operations is 3.4 per cent and in cases operated through MCBURNEY's incision (table 24) 1.3 per cent only.

If the relation of early and late operations performed according to different methods of incision to the predisposition to incisional herniae is determined statistically it will appear that, according to the above tables, the time of the operation with regard to each incision separately, is of no great importance. There may possibly be actual differences but this material does not prove it with statistical certainty:

$$\begin{aligned}
 \text{MCBURNEY's incision} & \begin{cases} 7.6 - 8.0 = -0.4 \pm 1.8 (0.2 \times 1.8 = 0.4) \\ 8.9 - 8.0 = +0.9 \pm 2.6 (0.3 \times 2.6 = 0.8) \end{cases} \\
 \text{LENNANDER's incision} & \begin{cases} 16.1 - 17.5 = -1.4 \pm 2.4 (0.6 \times 2.4 = 1.4) \\ 19.5 - 17.5 = +2.0 \pm 3.0 (0.7 \times 3.0 = 2.1) \end{cases} \\
 \text{KROGIUS's incision} & \begin{cases} 14.9 - 16.3 = -1.4 \pm 2.6 (0.5 \times 2.6 = 1.3) \\ 19.3 - 16.3 = +3.0 \pm 3.4 (0.9 \times 3.4 = 3.1) \end{cases}
 \end{aligned}$$

In order further to elucidate this matter we shall also compare the hernia percentages resulting from operations performed within the first day and later than 3 days after the onset of the disease

to one another. The difference with regard to the frequency of incisional herniae is, according to my material, 8.5 per cent. The corresponding difference in per cent for the different incisions (tables 24—26) is as follows: MCBURNEY's incision 6.6 per cent, LENNANDER's incision 8.5 per cent and KROGIUS's incision 9.1 per cent. From these percentages the conclusion may be drawn that *the predisposition to incisional herniae increases with the delay of the operation.*

The dependance of incisional herniae, as expressed by me, on the time of operation seems also statistically certain. *Also with regard to this question LENNANDER's and KROGIUS's incisions proved to be equivalent, although the ordinary incisional hernia percentage was, in cases of LENNANDER's incision, somewhat higher.*

3. *Factors which may cause an increase in the predisposition to incisional herniae by a prolonged interval between the onset of the disease and the operation.*

The increase of the predisposition to incisional herniae by a prolonged interval between the onset of the disease and the operation, may be partly explained as a result of intraperitoneal pathological changes. Although the inflammation develops at a different rate in different cases it must, however, be assumed that the later the operation is performed the more developed is the peritonitis and the various symptoms. In operations at an early stage the peritoneal exudate has many bactericide qualities and in most cases even the peritonitis which may possibly have developed, has fairly slight symptoms. In such cases there is generally no severe postoperative meteorism.

If we thus operate at an early stage when the appendix is still unperforated, the wound edges are protected against infection if we only follow the aseptic rules in general. At an early stage the intraperitoneal exudate formed as a result of the action of toxins, is free from bacteria, and does not infect the wound edges in connection with the operation. It could therefore be expected with great probability that the wound would heal primarily to the drain. Because there is no meteorism the wound edges are generally easily adapted without even the slightest tension, and consequently

a secure suture of the peritoneum and the abdominal layers should be expected. In these cases drainage is also generally of short duration which also entitles us to believe that the drainage tract will close without leaving any hernial opening.

In cases of more advanced appendicitis with peritonitis in which the appendix is already perforated, the possibilities for a development of incisional herniae are much greater. The exudate found in the peritoneal cavity infects the wound edges already during the operation, resulting during the period of healing in suppuration of the wound which was closed to the drain. In such cases it is often necessary to open a few sutures. The infection results in a weak spot in the abdominal wall. Meteorism which is often present in peritonitis and which is caused by a paralytic ileus may hamper the closure of the wound to such an extent that, in spite of every precaution, omentum or fat may penetrate between the sutures of the abdominal wall, or the distended coils of intestine may stretch the abdominal coats and, at the same time, the suture of the abdominal wall, causing separation of the edges or tearing of the sutures. Wound separation occurs generally more readily in the unelastic aponeurosis than in other layers of the abdominal wall which give way more easily to tension than the firm aponeurosis.

The drainage of purulent cases is generally also more prolonged than of cases of early operation, and leaves an open drainage tract without muscular protection. In cases operated through KROGIUS's incision the drainage is not protected by any muscular tissue and consequently the danger of incisional herniation is great. It has generally been established that in cases of MCBURNEY's and LËNNANDER's incision the muscular elasticity is preserved until 5—7 days after the operation. Therefore, if the drain is removed within this time, the muscle will withdraw and cover the tract.

On the basis of my theory as explained above, the increase in the frequency of incisional herniae as the result of a prolonged interval between the onset of the disease and the operation, is partly explained. It should be added that just as the general vitality and power of resistance of the patient influences the healing of the patient, so does also the general condition locally effect the healing of the wound. If the general condition of the patient is good from

the start, he overcomes the infection more easily and the vitality of the separate tissues as well as the power of resistance are good. — During the last years much has been published on the influence of vitamins and hormones on the healing of operation wounds. Sulfa-drugs and penicillin have also had a revolutionary influence upon the healing of operative incisions in cases of peritonitis.

As a summary we may state that an early operation gives the best result with regard to the occurrence of incisional herniae. If the operation is performed later than 48 hours from the onset of the symptoms, the frequency of incisional herniae increases depending on the incision by 1.3—4.4 per cent. It seems also statistically possible that the predisposition to incisional herniation increases if the interval between the onset of the disease and the operation is prolonged. After MCBURNEY'S incision the abdominal wall proved to be more firm also in cases of delayed operations.

The Occurrence of Incisional Herniae Following Operations at Different Stages of the Disease.

1. The relation between the occurrence of incisional herniae and the stage of development of the disease in general.

The question of the relation of the incisional herniae to the stage of the disease at the time of operation is closely connected with the relation of the incisional herniae to the day of operation, even though these problems cannot be quite compared due to factors which I have already mentioned. I have also explained why a smaller number of incisional herniae may generally be expected after operations at the appendicitis acuta non perforata stage than after operations performed at the stage of peritonitis. To what extent this theory holds good with regard to my material appears from the table 27.

When examining table 27 we notice that the percentage of incisional herniae in cases operated at the stage when only appendicitis was diagnosed is less than half of that in cases operated at a stage of diffuse peritonitis and of periappendicular abscesses.

TABLE 27. The occurrence of incisional herniae following operations at different stages of the disease.

Diagnosis	Number of operations	Number of incisional herniae	Percentage of incisional herniae	Percentage of mean error ε (p)
I. Appendicitis acuta non perforata	199	13	6.5	± 2.5
II. Appendicitis acuta perforata et peritonitis diffusa incipiens	366	56	15.3	± 1.8
III. Appendicitis acuta perforata et peritonitis diffusa universalis	414	70	17.0	± 1.7
IV. Abscessus periappendicularis ..	83	11	13.3	± 3.7
Total	1 062	150	14.1	± 1.1

$$\begin{aligned}
 & \text{I. } 6.5 - 14.1 = -7.6 \pm 2.5 \quad (3.0 \times 2.5 = 7.5) \\
 & \text{II. } \left. \begin{array}{l} \\ \end{array} \right\} 16.2 - 14.1 = +2.1 \pm 1.2 \quad (1.7 \times 1.2 = 2.0) \\
 & \text{III. } \left. \begin{array}{l} \\ \end{array} \right\} \\
 & \text{IV. } 13.3 - 14.1 = -0.8 \pm 3.7 \quad (0.2 \times 3.7 = 0.7)
 \end{aligned}$$

According to my material it is also statistically certain that a low percentage of incisional herniae is characteristic of cases operated at a stage of acute nonperforated appendicitis, this percentage thus not being incidental. It is also statistically possible that the large percentage of incisional herniae of the peritonitis diffusa stage corresponds with facts. Due to the small number of cases no absolute conclusions can be drawn with regard to cases operated in a stage of abscess. It seems generally possible that the predisposition to incisional herniae grows with the development of the stage of the disease.

2. The relation between the occurrence of incisional herniae and the stage of development of the disease with regard to different incisions.

When examining the relation between the stage of development of the disease and the incisional herniae when different incisions have been employed, we shall note the following:

TABLE 28. The occurrence of incisional herniae following operations at different stages of the disease through McBURNEY's incision.

Diagnosis	Number of operations	Number of incisional herniae	Percentage of incisional herniae	Percentage of mean error ϵ (p)
I. Appendicitis acuta non perforata	63	4	6.4	± 3.4
II. Appendicitis acuta perforata et peritonitis diffusa incipiens	104	7	6.7	$\left. \begin{array}{l} \\ \end{array} \right\} \pm 1.7$
III. Appendicitis acuta perforata et peritonitis diffusa universalis	152	15	9.9	
IV. Abscessus periappendicularis..	29	2	6.9	± 5.0
Total	348	28	8.0	± 1.4

In cases operated through McBURNEY's incision (table 28) there is evidently an equal percentage (6.4—6.9 percent) of incisional herniae after operations at the acute stage of appendicitis and at the abscess stage, whereas there appears to be more incisional herniae (8.6 per cent) after the peritonitis diffusa stage. *On the basis of my material, however, nothing statistically certain can be established regarding the relation of the predisposition to incisional herniation and the stage of development of the disease in cases of McBURNEY's incision.* As appears from the following expressions the hernia percentages of the different groups of diagnoses vary within the limits of the mean error.

$$\begin{array}{l}
 \text{I. } 6.4 - 8.0 = -1.6 \pm 3.4 \quad (0.3 \times 3.4 = 1.7) \\
 \left. \begin{array}{l} \text{II.} \\ \text{III.} \end{array} \right\} 8.6 - 8.0 = +0.6 \pm 1.7 \quad (0.3 \times 1.7 = 0.5) \\
 \text{IV. } 6.9 - 8.0 = -1.1 \pm 5.0 \quad (0.2 \times 5.0 = 1.0)
 \end{array}$$

As to the percentages of incisional herniae in men and women at different stages of development of the disease, they vary in the same way.

In cases of LENNANDER's incision (table 29) the difference in the predisposition to incisional herniae after operations performed at the appendicitis non-perforata stage, the diffuse peritonitis and the periappendicular abscess stage is very large. *When examining*

TABLE 29. The occurrence of incisional herniae following operations at different stages of the disease through LENNANDER's incision.

Diagnosis	Number of operations	Number of incisional herniae	Percentage of incisional herniae	Percentage of mean error ε (p)
I. Appendicitis acuta non perforata	83	7	8.4	± 4.2
II. Appendicitis acuta perforata et peritonitis diffusa incipiens	153	23	15.0	± 2.2
III. Appendicitis acuta perforata et peritonitis diffusa universalis	136	33	24.3	
IV. Abscessus periappendicularis ..	29	7	24.1	± 6.9
Total	401	70	17.5	± 1.9

statistically the relation between different groups of diagnoses, the small predisposition to incisional herniae at the stage of acute non-perforated appendicitis seems almost certain, and that of the diffuse peritonitis and the abscess stage is equal with regard to the occurrence of incisional herniae. The smallness of the material again prevents the drawing of definite conclusions.

$$\begin{aligned}
 & \text{I. } 8.4 - 17.5 = -9.1 \pm 4.2 \quad (2.2 \times 4.2 = 9.2) \\
 & \text{II. } \left. \begin{array}{l} 19.5 - 17.5 = +2.0 \pm 2.2 \quad (0.9 \times 2.2 = 2.0) \\ \text{III.} \end{array} \right\} \\
 & \text{IV. } 24.1 - 17.5 = +6.6 \pm 6.9 \quad (0.9 \times 6.9 = 6.2)
 \end{aligned}$$

In cases of LENNANDER's incision the percentages of incisional herniae of men and women in the same stages of development of the disease vary correspondingly.

As appears from table 30 the percentages of incisional herniae at different stages of the disease vary almost to the same extent as in cases of LENNANDER's incision.

$$\begin{aligned}
 & \text{I. } 3.8 - 16.3 = -12.5 \pm 5.0 \quad (2.5 \times 5.0 = 12.5) \\
 & \text{II. } \left. \begin{array}{l} 20.4 - 16.3 = + 4.1 \pm 2.4 \quad (1.7 \times 2.4 = 4.1) \\ \text{III.} \end{array} \right\} \\
 & \text{IV. } 8.0 - 16.3 = - 8.3 \pm 6.7 \quad (1.2 \times 6.7 = 8.0)
 \end{aligned}$$

TABLE 30. The occurrence of incisional herniae following operations at different stages of the disease through KROGIUS's incision.

Diagnosis	Number of operations	Number of incisional herniae	Percentage of incisional herniae	Percentage of mean error ε (p)
I. Appendicitis acuta non perforata	53	2	3.8	± 5.0
II. Appendicitis acuta perforata et peritonitis diffusa incipiens	109	26	23.9	$\left. \begin{array}{l} 20.4 \\ \pm 2.1 \end{array} \right\}$
III. Appendicitis acuta perforata et peritonitis diffusa universalis	126	22	17.5	
IV. Abscessus periappendicularis ..	25	2	8.0	± 6.7
Total	313	52	16.3	± 2.1

Statistically it seems almost certain that there is a low predisposition to incisional herniae in cases operated at the acute non-perforated stage. The high predisposition to incisional herniation at the diffuse peritonitis stage is statistically possible whereas no definite conclusions of the results of the abscess stage can be drawn on the basis of my material owing to its smallness.

The variation in the hernia percentages for men and women is the same in the corresponding stages of disease also in cases of KROGIUS's incision.

TABLE 31. The occurrence of incisional herniae at different stages of the disease in cases operated through LENNANDER's and KROGIUS's incision.

Diagnosis	Number of operations	Number of incisional herniae	Percentage of incisional herniae	Percentage of mean error ε (p)
I. Appendicitis acuta non perforata	136	9	6.6	± 3.1
II. Appendicitis acuta perforata et peritonitis diffusa incipiens	262	49	18.7	$\left. \begin{array}{l} 19.8 \\ \pm 1.6 \end{array} \right\}$
III. Appendicitis acuta perforata et peritonitis diffusa universalis	262	55	21.0	
IV. Abscessus periappendicularis ..	54	9	16.7	± 5.3
Total	714	122	17.1	± 1.5

It seems as if the cases operated through LENNANDER's and KROGIUS's incision react with regard to incisional herniation in the same way also in respect to the stage of the disease, so I have combined both these statistics (table 31) in order to ascertain whether this larger material allows more exact conclusions to be drawn for the elucidation of the problem. From the expressions obtained in this way appears that *the low predisposition to incisional herniae in cases operated at the acute non-perforated stage is also statistically quite certain and that the high predisposition to incisional herniae at the peritonitis diffusa stage is statistically possible.*

$$\begin{array}{l} \text{I. } 6.6 - 17.1 = -10.5 \pm 3.1 \quad (3.4 \times 3.1 = 10.5) \\ \text{II. } \left. \begin{array}{l} 19.8 - 17.1 = + 2.7 \pm 1.6 \quad (1.7 \times 1.6 = 2.7) \\ \text{III. } \end{array} \right\} \\ \text{IV. } 16.7 - 17.1 = - 0.4 \pm 5.3 \quad (0.07 \times 5.3 = 0.4) \end{array}$$

The Relation of the Duration of Drainage to the Occurrence of Incisional Herniae.

1. The relation of the duration of drainage to the occurrence of incisional herniae in general.

The prevalent opinion among surgeons is that the longer the period of drainage and the thicker the drain, the higher is the frequency of incisional herniae. Table 32 shows the distribution of my total material of incisional herniae according to the duration of the drainage:

TABLE 32. The relation of the duration of drainage to the frequency of incisional herniae.

Maximum lapse of time between operation and removal of drain	Number of operations	Number of incisional herniae	Percentage of incisional herniae	Percentage of mean error ϵ (p)
24 hours	75	10	13.3	} ± 1.8
48 »	141	17	12.1	
72 »	149	14	9.4	
5 days	207	27	13.4	} ± 1.3
7 » or more ..	490	82	16.7	
Total	1 062	150	14.1	± 1.1

The smallness of my material again hampers the determining of the difference between the separate minor sub-groups. If the cases are treated in larger groups, however, we find an evident difference on the basis of the duration of drainage. *If the drain has been removed 3 days at the latest after the operation the percentage of incisional herniae is 11.2, whereas in cases in which the drain was allowed to remain longer in the wound incisional herniation occurs in 15.6 per cent of all cases.* It seems also statistically possible that the predisposition to incisional herniae grows with the length of the period of drainage:

$$11.2 - 14.1 = -2.9 \pm 1.8 \quad (1.6 \times 1.8 = 2.9)$$

$$15.6 - 14.1 = +1.5 \pm 1.3 \quad (1.2 \times 1.3 = 1.5)$$

We must, however, also consider the fact that cases with a prolonged drainage are generally more serious than those drained during a shorter period. This appears from table 33 (cf. p. 167) which throws light upon the influence of the duration of drainage on the frequency of incisional herniae in patients operated at different stages of the disease. *When examining separately the cases in which the drainage lasted 3 days at the most, and those with a longer period of drainage, we shall find that for the same periods of drainage the frequency of incisional herniae increases in both groups as the stage of the disease becomes more serious* (cf. p. 89). The development of the predisposition to incisional herniation on these lines is also statistically possible:

Drainage of maximum 3 days

Diagnosis	I	$2.3 - 14.1 = -11.8 \pm 3.7$	$(3.2 \times 3.7 = 11.8)$
	II	$13.5 - 14.1 = -0.6 \pm 3.1$	$(0.2 \times 3.1 = 0.6)$
	III	$16.4 - 14.1 = +2.3 \pm 3.0$	$(0.8 \times 3.0 = 2.4)$
	II + III	$15.0 - 14.1 = +0.9 \pm 2.2$	$(0.4 \times 2.2 = 0.9)$

Drainage for more than 3 days

Diagnosis	I	$9.9 - 14.1 = -4.2 \pm 3.3$	$(1.3 \times 3.3 = 4.3)$
	II	$16.3 - 14.1 = +2.2 \pm 2.2$	$(1.0 \times 2.2 = 2.2)$
	III	$17.1 - 14.1 = +3.0 \pm 2.1$	$(1.4 \times 2.1 = 2.9)$
	II + III	$16.7 - 14.1 = +2.6 \pm 1.5$	$(1.7 \times 1.5 = 2.6)$

Based on the above we may state that *infection plays an important rôle for the frequency of incisional herniae in drained cases. This fact is also evident when we examine the relation of the duration of drainage to the frequency of incisional herniae for each operative diagnosis separately.* We shall find that in each group the predisposition to herniation grows as the period of drainage is prolonged, which further proves that drainage itself is partly responsible for the occurrence of incisional herniae. This is in my opinion also indicated by the fact that the greatest difference in the frequency of incisional herniae is found in patients operated at the acute non-perforated stage when cases with drainage of maximum 3 days and more than 3 days are compared. The fact that this difference is not very great in cases operated at the peritonitis stage proves that the influence of drainage is not in these cases so marked because the frequency of incisional herniae is here due to the disease itself and to the infection caused by it, and is remarkably large even after drainage of short duration. — *When drawing conclusions with regard to the relation of the duration of drainage to the occurrence of incisional herniae, infection and its consequences should also be considered.*

2. *The relation of the duration of drainage to the occurrence of incisional herniae in cases operated through different incisions.*

The influence of drainage with regard to the different incisions seem also to be the same as related in the preceding chapter.

TABLE 34. The influence of drainage on the occurrence of incisional herniae in cases of MCBURNEY'S incision.

Maximum lapse of time between operation and removal of drain	Number of operations	Number of incisional herniae	Percentage of incisional herniae	Percentage of mean error ϵ (p)
24 hours	15	—	—	} ± 2.9
48 »	29	3	10.3	
72 »	44	1	2.3	
5 days	58	4	6.9	} ± 1.7
7 » or more . .	202	20	9.9	
Total	348	28	8.0	± 1.4

In cases of MCBURNEY'S incision (table 34) the frequency of incisional herniae in patients from which the drain was removed within 72 hours after the operation, is 4.5 per cent, whereas it is 9.2 per cent in cases with a drainage of longer duration, thus twice as large, which also seems to be statistically possible:

$$4.5 - 8.0 = -3.5 \pm 2.9 \quad (1.2 \times 2.9 = 3.5)$$

$$9.2 - 8.0 = +1.2 \pm 1.7 \quad (0.7 \times 1.7 = 1.2)$$

TABLE 35. The influence of drainage on the occurrence of incisional herniae in cases of LENNANDER'S incision.

Maximum lapse of time between operation and removal of drain	Number of operations	Number of incisional herniae	Percentage of incisional herniae	Percentage of mean error ϵ (p)
24 hours	7	—	—	} ± 4.0
48 »	41 } 89	4 } 10	9.8 } 11.2	
72 »	41	6	14.6	
5 days	92 } 312	12 } 60	14.1 } 19.2	} 2.1
7 » or more ..	220	48	21.7	
Total	401	70	17.5	± 1.9

In cases of LENNANDER'S incision (table 35) the predisposition to incisional herniae grows also considerably as drainage is prolonged. If the drain is removed within 3 days after the operation, incisional herniation occurs in 11.2 per cent of the cases, whereas 19.2 per cent of the cases develop incisional herniae when the drainage is prolonged.

With regard to LENNANDER'S incision it seems also statistically possible that the prolongation of drainage adds to the predisposition to incisional herniation:

$$11.2 - 17.5 = -6.5 \pm 4.0 \quad (1.6 \times 4.0 = 6.4)$$

$$19.2 - 17.5 = +1.7 \pm 2.1 \quad (0.8 \times 2.1 = 1.7)$$

In cases of KROGIUS'S incision the frequency of incisional herniae seems to be particularly dependent on the duration of drainage (table 36). Incisional herniae occur in 14.4 per cent of the cases drained during the first three days, whereas the percentage rises to 24.0 for those drained during a longer period.

TABLE 36. The influence of drainage on the occurrence of incisional herniae in cases of KROGIUS's incision.

Maximum lapse of time between operation and removal of drain	Number of operations	Number of incisional herniae	Percentage of incisional herniae	Percentage of mean error ϵ (p)
24 hours	53	10	18.9	} ± 2.6
48 »	71	10	14.1	
72 »	64	7	10.9	
5 days	57	11	19.3	} ± 3.3
7 » or more ..	68	19	28.0	
Total	313	52	16.3	± 2.1

It is also statistically almost certain that prolongation of the drainage during more than 3 days causes a considerable increase in the predisposition to incisional herniae:

$$14.4 - 16.3 = -1.9 \pm 2.6 \quad (0.7 \times 2.6 = 1.8)$$

$$24.0 - 16.3 = +7.7 \pm 3.3 \quad (2.3 \times 3.3 = 7.6)$$

As a summary of the foregoing we may say that prolonged drainage generally increases the predisposition to incisional herniae. The period of drainage being the same, the predisposition to herniae increases as the stage of the disease grows worse.

When comparing then the different incisions on the basis of how they stand drainage we find MCBURNEY's incision to be the best. When drainage lasted more than 3 days the frequency of incisional herniae in cases of MCBURNEY's incision is only half of that in cases of LENNANDER's and one third of KROGIUS's incision. The reason for this is probably that in MCBURNEY's incision the wound which is made in the course of the muscle fibers is closed, after the removal of the drain, as a result of muscular tension.

When comparing the cases of LENNANDER's and KROGIUS's incision we will find that we cannot from the present material statistically draw any conclusions, as the percentages of incisional herniae of these incisions resulting from the period of drainage, vary within the limits of the mean error, as appears from the following expressions:

Drain removed within 3 days after the operation.

LENNANDER's incision $11.2 - 17.1 = -5.9 \pm 4.0$ ($1.5 \times 4.0 = 6.0$)

KROGIUS's incision $14.4 - 17.1 = -2.7 \pm 2.6$ ($1.0 \times 2.6 = 2.6$)

Drain removed later than 3 days after the operation.

LENNANDER's incision $19.2 - 17.1 = +2.1 \pm 2.1$ ($1.0 \times 2.1 = 2.1$)

KROGIUS's incision $24.0 - 17.1 = +6.9 \pm 3.3$ ($2.1 \times 3.3 = 6.9$)

It seems, however, statistically almost certain that KROGIUS's incision stands drainage of more than 3 days' duration less well than does LENNANDER's.

Renewed Operations Caused by Incisional Herniae.

It appears clearly from the foregoing that the firmness of the abdominal wall greatly depends on the kind of incision used, and the difference appears from the frequency of incisional herniae or the predisposition to incisional herniation. As the incisions dealt with in my investigation are located to abdominal areas of different structure, I have also investigated to what extent incisional herniae following different incisions inconvenience the bearers. In order to determine this circumstance I have used information of renewed operations caused by incisional herniae.

It appears from table 37 that *the greatest number of renewed operations because of incisional herniae (54.3 per cent) occurred in cases in which LENNANDER's incision had originally been employed. The second largest number of renewed operations (48.1 per cent) followed KROGIUS's incision. The fewest (25 per cent) renewed operations were performed in cases of MCBURNEY's incision, and here only in cases of strangulation.* When comparing the percentages of renewed operations caused by incisional herniae of different incisions, the relation between these incisions is the same as in connection with the previous questions. *The percentage of renewed operations after MCBURNEY's incision is about half of that of LENNANDER's and KROGIUS's incisions, viz. the incisional herniae which develop after MCBURNEY's incision are of less inconvenience to the bearers than those developing after the other incisions dealt with in this investigation.* This circumstance seems also to be statistically almost certain as appears from the following expressions:

TABLE 37. Number of renewed operations because of incisional herniae following different incisions.

Nature of the appendectomy incision	Number of operations	Number of incisional herniae	Number of renewed operations	Percentage of renewed operations as compared with the number of incisional herniae	Percentage of mean error ε (p)	Percentage of renewed operations as compared with the number of primary operations	Percentage of mean error ε (p)
McBURNAY'S incision	348	28	7	25.0	± 9.1	2.0	± 1.4
LENNANDER'S incision	401	70	38	54.3	± 6.0	9.5	± 1.2
KROGIUS'S incision	313	52	25	48.1	± 7.1	8.0	± 1.4
					± 4.6		± 1.2
Total	1 062	150	70	46.7	± 4.1	6.6	± 0.8

McBURNAY'S incision $25.0 - 46.7 = -21.7 \pm 9.1$ ($2.4 \times 9.1 = 21.8$)

LENNANDER'S incision $54.3 - 46.7 = + 7.6 \pm 6.0$ ($1.3 \times 6.0 = 7.8$)

KROGIUS'S incision $48.1 - 46.7 = + 1.4 \pm 7.1$ ($0.2 \times 7.1 = 1.4$)

LENNANDER'S } incision $51.7 - 46.7 = + 5.0 \pm 4.6$ ($1.1 \times 4.6 = 5.1$)

KROGIUS'S

If we consider how many of the primary operations must be followed by renewed operations on account of incisional herniae we shall obtain, as appears from table 37, the following percentages for the different incisions:

McBURNAY'S incision 2.0 per cent

LENNANDER'S incision 9.5 per cent

KROGIUS'S incision 8.0 per cent

Renewed operations for incisional herniae following McBURNAY'S incision are thus four times less frequent than after other incisions. The superiority of McBURNAY'S incision is also statistically certain. The great percentage of renewed operations for incisional herniae in cases of LENNANDER'S incision is statistically almost certain.

$$2.0 - 6.6 = -4.6 \pm 1.4 \quad (3.3 \times 1.4 = 4.6)$$

$$9.5 - 6.6 = +2.9 \pm 1.2 \quad (2.5 \times 1.2 = 3.0)$$

$$8.0 - 6.6 = +1.4 \pm 1.4 \quad (1.0 \times 1.4 = 1.4)$$

The most important reasons for renewed operations of incisional herniae are the same as for other herniae, viz. incarceration of the hernia and pain and other disturbances caused by adhesions developing at the hernial orifice and sac.

According to LEHMANN (1941) strangulation of incisional herniae is possible when the hernial orifice is small and sharp-edged whereas the subjective symptoms do not as in cases of other kinds of herniae, depend on the size of the hernia. It should be mentioned that GIERTZ's (1909) statistics which comprised 533 cases of appendicitis with peritonitis mostly operated through an oblique incision of the inguinal ligament, did not show a single case of hernial strangulation.

It should further be noticed that the oblique incision used in GIERTZ's material was made by the muscle fibers being divided either sharply or bluntly from the inguinal ligament or the crista ilica. The size of the herniae varied between that of a cherry to that of a man's head and depending on the location of the incision the hernial orifice stretched as the tension of the abdominal layers increased.

In my material the reasons for renewed operations because of incisional herniae will to the greatest part remain unrevealed. I have only obtained information as to a possible strangulation of the herniae.

When examining table 38 we notice in particular the fact that *strangulation occurs much more frequently (25 per cent) in incisional*

TABLE 33. The occurrence of strangulation of incisional herniae following different incisions.

Incision	Number of incisional herniae	Number of cases of strangulation	Percentage of strangulation	Percentage of mean error ϵ (p)
McBURNAY's incision ..	28	7	25.0	± 6.9
LENNANDER's incision ..	70	11	15.7	± 4.5
KROGIUS's incision	52	8	15.4	± 5.4
	122		15.6	± 3.4
Total	150	26	17.3	± 3.1

herniae following McBURNEY's incision than in incisional herniae after other incisions (15.7 — 15.4 per cent). LENNANDER's and KROGIUS's incisions seem to be equal also in this respect.

To what extent the variations between the different incisions with regard to the strangulation are statistically confirmed, appears from the following expressions:

McBURNEY's incision	$25.0 - 17.3 = +7.7 \pm 6.9$	$(1.1 \times 6.9 = 7.6)$
LENNANDER's incision	$15.7 - 17.3 = -1.6 \pm 4.5$	$(0.4 \times 4.5 = 1.8)$
KROGIUS's incision	$15.4 - 17.3 = -1.9 \pm 5.4$	$(0.4 \times 5.4 = 2.1)$
LENNANDER's incision	$15.6 - 17.3 = -1.7 \pm 3.4$	$(0.5 \times 3.4 = 1.7)$
KROGIUS's incision		

One cannot therefore on the basis of this material, draw any statistically certain conclusions as to the frequency of strangulation in cases of different incisions, although it seems as if LENNANDER's and KROGIUS's incisions are equal in this respect, both differing from McBURNEY's incision.

The reason for the large percentage of strangulation of McBURNEY's incision must be sought in the anatomical structure of the abdominal wall. The muscle and aponeurosis fibers running crosswise exercise a greater pressure upon the hernia than do the wound edges in LENNANDER's and KROGIUS's incisions. Thus the factor which greatly prevents the formation of incisional herniae has a greatly negative influence on herniae which have already developed, whereas in cases of LENNANDER's and KROGIUS's incisions the lateral tension widens still more the hernial orifice. The influence of the intra-abdominal pressure on herniae following all these incisions may probably be considered equally large.

In summing up it may be stated that incisional herniae resulting from McBURNEY's incision more frequently become strangulated than incisional herniae following LENNANDER's and KROGIUS's incisions. But if other disturbances caused by incisional herniae are considered, those following LENNANDER's and KROGIUS's incisions are of greater inconvenience to the carriers than those resulting from McBURNEY's incision. This appears from the fact that incisional herniae following McBURNEY's incision do not require a renewed operation in more than half of the cases as compared with the incisional herniae of the other

incisions dealt with in this investigation. When the relation of renewed operations for incisional herniae to primary operations is considered, LENNANDER's and KROGIUS's incisions caused renewed operations four times more often than MCBURNEY's incision.

In my opinion the elucidation of this question also confirms the reliability of the replies of the patients with regard to incisional herniae. The percentages of renewed operations of the different incisions with regard to the number of incisional herniae and primary operations correspond entirely to the results of comparisons between these incisions obtained in connection with the elucidation of other questions. Therefore, although my material is based only on after-inquiries and not on personal after-examinations of the patients, I believe that conclusions referring to differences between the various incisions in regard to the firmness of the abdominal wall, may be drawn on the basis of this material.

II.

THE RELATION OF INGUINAL HERNIAE TO AN EARLIER OPERATION FOR APPEN- DICITIS WITH PERITONITIS.

Appendectomy has sometimes been alleged to cause even the occurrence of inguinal herniae. I have therefore also considered this problem when drawing up the questionnaires and collecting my material. I have tried to find *how many patients in my material have developed inguinal hernia after the discharge from hospital.* I have not been able to consider the time of occurrence of the inguinal hernia as most of the patients have not remembered it exactly.

General Factors Influencing the Occurrence of Inguinal Herniae.

The factors influencing the development of inguinal herniae are generally considered to be hereditary. Thus *the internal oblique and the transversalis may be attached to the rectus sheath at a higher level than normally* in which case the trigonum inguinale would be covered only by the peritoneum and skin, or *the vaginal process may be partly or totally open*, and give rise to hernia. Normally this formation should be closed by the end of the fourth fetal month in women and 1 month after the birth in men.

Further *constitutional factors* are also considered important for the development of inguinal herniae. Individuals with a general weakness in the connective and muscular tissues develop herniae more rapidly than others. HUECK and EMMERICH have investigated

this matter stating that out of 750 inguinal herniae 12 per cent occurred in asthenics, 17.6 per cent in athletics and 18 per cent in pyknics. The results are thus quite contrary to what is generally supposed with regard to the firmness of the tissues of asthenics and pyknics. The quality of the muscles of a pyknic is considerably poorer than that of an asthenic and it grows worse with increasing age when fat develops in the muscular tissue. *Rapid loss of weight* also furthers herniation.

Factors which favour the manifestation of a tendency to inguinal herniation are, according to literature, *scars in the abdominal wall* and particularly *an occupation which demands spasmodic use of the abdominal muscles* thereby pushing the contents of the abdominal cavity into the hernial orifices (GARRE & BORCHARD & STICH, 1935).

According to literature appendectomies — as already mentioned in the foregoing — *play an important rôle in the manifestation of hidden tendencies to herniation*. An incision which severs the ilio-inguinal and the iliohypogastric nerves is generally considered to cause postoperative inguinal herniation. These nerves supply the muscles and aponeuroses of the area of inguinal herniae, and injury to them either through an operation or through the pressure of a drain may cause atrophy of the muscle tissue. Scar tension may also injure the muscle tissue. Inguinal herniae have occurred particularly in purulent drained cases (BRETTE 1942).

The Frequency of Inguinal Herniae Following Appendectomy According to Literature.

The percentages of inguinal herniae following appendectomies established by other authors cannot be quite compared with the results of my material as these are not homogenous. Thus FOWLER (1914), for instance, has included both drained and undrained cases in his material. HOGUET (1911) and MAESSE (1920) have given no information whatever as to whether their cases are drained or not. Further HOGUET does not mention the type of incision. I have, however, mentioned the results of these authors merely in order to show the general frequency of inguinal herniae as a result of appendectomy.

In GIERTZ's statistics of 533 operations for appendicitis with peritonitis there are 8 cases of inguinal herniae, 6 right, 1 double and 1 left inguinal hernia. In most cases the hernia developed within a year after the appendectomy. All GIERTZ's cases were operated through an oblique incision in the course of the inguinal ligament.

HOGUET mentions that of 190 right inguinal herniae 8 (4.2 per cent) appeared after appendectomy. He considers the reason for this to be injury to the ilio-inguinal and the iliohypogastric nerves in connection with appendectomy. FOWLER also regards injury to these nerves the cause of the development of inguinal herniae after appendectomy. Out of 785 right inguinal herniae of the Mayo Clinic 17 (2.2 per cent) occurred after appendectomy. In all cases MCBURNEY's incision was employed, and in most cases drainage had been administered through the operative wound.

Also MINTZ (1914), MAESSE (1920), GERTKEMPER (1928), MERMINGAS (1928) and MARTIARENA (1938) have described the part played by injury to the mentioned nerves in the manifestation of a hidden inguinal hernia.

The Occurrence of Inguinal Herniae in my Material after Appendectomies Performed at Different Stages of the Disease.

On the basis of the facts related in the foregoing I have tried to investigate to what extent in my material inguinal herniae have occurred after appendectomies with drainage and to what extent the incision employed in the operation possibly influences the occurrence of inguinal herniae. I have paid great attention to right inguinal herniae because their occurrence may somehow be anatomically and physiologically explained, whereas there is not, in my opinion, sufficient reason for the occurrence of left inguinal herniae after a previous appendectomy. It might be possible, of course, that meteorism caused by the peritonitis stretches the abdominal layers weakened by the disease and, at the same time, also congenital hernial orifices.

TABLE 39. The occurrence of right inguinal herniae after appendectomies performed at different stages of the disease.

Diagnosis	Number of operations	Number of inguinal herniae	Percentage of inguinal herniae	Percentage of mean error ε (p)
I. Appendicitis acuta non perforata	199	2	1.0	± 1.1
II. Appendicitis acuta perforata et peritonitis diffusa incipiens	366	6	1.6	± 0.8
III. Appendicitis acuta perforata et peritonitis diffusa universalis	414			
IV. Abscessus periappendicularis..	83	—	—	—
Total	1 062	25	2.4	± 0.4

After the 1 062 appendectomies of my material 25 right inguinal herniae (2.4 per cent, table 39) have occurred. The patients who developed inguinal herniae were 4 women and 21 men, and their average age was 31 years. Most herniae (23) occurred after operations performed at the peritonitis diffusa stage which indicates that the incision and the duration of the drainage as well as the injury by the disease to the abdominal wall, have been of a decisive influence upon the development of the hernia. There is only one case of right inguinal hernia following an operation at the non-perforated stage. After appendectomies at the abscess stage no inguinal herniae occurred but due to the scarcity of the cases in this group, this may be quite incidental.

On examining the influence of the period of drainage on the occurrence of right inguinal herniae we find that out of 25 inguinal herniae 23 developed in cases which were drained at least 5 days. In $\frac{2}{3}$ of the cases of peritonitis diffusa the drainage exceeded 5 days.

My material indicates further that *the factor at which stage of the disease appendectomy was performed, also influenced the development of inguinal herniae*. Thus right inguinal herniae occurred only in 1.6 per cent of the cases operated at the peritonitis diffusa incipiens stage, whereas they are considerably more frequent, 4.1 per cent, after operations at the peritonitis diffusa universalis stage. As the duration of drainage in the cases of both these groups was

approximately of equal length, the reason for the increase in percentage of inguinal herniae must lie with the length of the incision and the stage of the disease. Peritonitis diffusa universalis must injure the abdominal wall to a far greater extent than peritonitis diffusa incipiens. It might be possible that meteorism of the paralytic intestine stretches congenitally weak hernial openings through which, due to some reason, a hernia protrudes. It should be mentioned that 4 patients developed right inguinal herniae and incisional herniae simultaneously. *It is also statistically almost certain that the possibilities for an occurrence of incisional herniae greatly increase as the stage of development of the disease grows worse, a fact which appears from the following expressions:*

Diagnosis	I	.....	1.0 — 2.4 = -1.4 ± 1.1	(1.3 $\times$ 1.1 = 1.4)
»	II	.....	1.6 — 2.4 = -0.8 ± 0.8	(1.0 $\times$ 0.8 = 0.8)
»	III	.....	4.1 — 2.4 = $+1.7 \pm 0.8$	(2.1 $\times$ 0.8 = 1.7)
»	II}	.....	2.9 — 2.4 = $+0.5 \pm 0.5$	(1.0 $\times$ 0.5 = 0.5)
»	III}			

The Relation of Different Appendectomy Incisions to the Occurrence of Inguinal Herniae on the Basis of my Material.

TABLE 40. The frequency of right inguinal herniae following MCBURNEY'S incision at different stages of the disease.

Diagnosis	Number of operations	Number of inguinal herniae	Percentage of inguinal herniae	Percentage of mean error ε (p)
I. Appendicitis acuta non perforata	63	1	1.6	± 1.3
II. Appendicitis acuta perforata et peritonitis diffusa incipiens	104	2	1.9	± 1.7
III. Appendicitis acuta perforata et peritonitis diffusa universalis	152	9	5.9	± 1.4
IV. Abscessus periappendicularis ..	29	—	—	—
Total	348	12	3.4	± 1.0

In examining the occurrence of right inguinal herniae in cases of MCBURNEY'S incision (table 40) we find that herniation occurred in 12 cases or 3.4 per cent out of 348 (MAESSE 3.6 per cent). Also here the incisional herniae occur most frequently after operations at the peritonitis diffusa stage. The drainage lasted more than 5 days in most of the cases. *The frequency of inguinal herniae following operations at the peritonitis diffusa universalis stage (5.9 per cent) is much greater than that following operations at the peritonitis diffusa incipiens stage (1.9 per cent).* The probable reason for this, as I have already mentioned, is injury to the abdominal wall caused by severe peritonitis and stretching of the hernial orifice. In connection with MCBURNEY'S incision there is also the fact that severing of the ilio-inguinal and the iliohypogastric nerves by the long incision, causes partial atrophy of the lower portion of the flat abdominal muscles which in turn results in the abdominal wall giving way more than normally to intra-abdominal pressure in this area.

We will also find that the different groups of diagnoses vary statistically in relation to the development of inguinal herniae although it is not possible within the range of this investigation to determine an exact statistical difference.

Diagnosis	I	.....	$1.6 - 3.4 = -1.8 \pm 1.3$	$(1.4 \times 1.3 = 1.8)$
»	II	.....	$1.9 - 3.4 = -1.5 \pm 1.7$	$(0.9 \times 1.7 = 1.5)$
»	III	.....	$5.9 - 3.4 = +2.5 \pm 1.4$	$(1.8 \times 1.4 = 2.5)$
»	II }	.....	$4.3 - 3.4 = +0.9 \pm 1.1$	$(0.8 \times 1.1 = 0.9)$
»	III }			

In the group of LENNANDER'S incision (table 41) there are 10 right inguinal herniae or 2.5 per cent out of 401 operations (MAESSE 5.03 per cent). All herniae occurred in cases operated at the peritonitis diffusa stage. In 9/10 of the cases drainage lasted longer than 5 days. The relation of operations at the peritonitis diffusa incipiens and the peritonitis diffusa universalis stage to the occurrence of right inguinal herniae is the same in cases of LENNANDER'S incision as in those of MCBURNEY'S incision. *The frequency of inguinal herniae increases considerably as the stage of the peritonitis grows worse.*

Since in LENNANDER'S incision neither the ilio-inguinal nor the iliohypogastric nerve is severed, the reason for inguinal herniae

TABLE 41. The frequency of right inguinal herniae following LENNANDER's incision at different stages of the disease.

Diagnosis	Number of operations	Number of inguinal herniae	Percentage of inguinal herniae	Percentage of mean error ε (p)
I. Appendicitis acuta non perforata	83	—	—	—
II. Appendicitis acuta perforata et peritonitis diffusa incipiens	153	5 } 10	2.6	± 1.3 } + 0.9
III. Appendicitis acuta perforata et peritonitis diffusa universalis	136		5.1	
IV. Abscessus periappendicularis ..	29		—	
Total	401	10	2.5	± 0.8

must be sought elsewhere. A long incision and the scar it leaves probably causes certain functional disturbances in the abdominal wall which result in herniae occurring easier in persons predisposed to herniation. The reason may sometimes also be found in atrophy of the medial portion of the right rectus muscle as a result of a long LENNANDER's incision.

It is also statistically possible that the high percentage of inguinal herniae following LENNANDER's incision at the peritonitis diffusa stage is not incidental but is characteristic of this class of diagnoses. No definite conclusions can be drawn with regard to the other classes of diagnoses on the basis of this material.

Diagnosis	II	.....	$2.0 - 2.5 = -0.5 \pm 1.3$	$(0.4 \times 1.3 = 0.5)$
»	III	.....	$5.1 - 2.5 = +2.6 \pm 1.3$	$(2.0 \times 1.3 = 2.6)$
»	II } III }	.....	$3.5 - 2.5 = +1.0 \pm 0.9$	$(1.1 \times 0.9 = 1.0)$

Right inguinal herniae have occurred only in 1 per cent of the cases operated through KROGIUS's incision (table 42). There is no noticeable difference between the operations of the peritonitis diffusa stage. In cases of inguinal herniae following the II stage drainage lasted 2 days and following the III stage 7 days. *In case the rare occurrence of inguinal herniae in connection with KROGIUS's incision be incidental, the share of this incision in the manifestation of inguinal herniae is non-existent.*

TABLE 42. The frequency of right inguinal herniae following KROGIUS's incision at different stages of the disease.

Diagnosis	Number of operations	Number of inguinal herniae	Percentage of inguinal herniae	Percentage of mean error ε (p)
I. Appendicitis acuta non perforata	53	1	1.9	± 1.4
II. Appendicitis acuta perforata et peritonitis diffusa incipiens	109	1	0.9	± 1.0
III. Appendicitis acuta perforata et peritonitis diffusa universalis	126	1	0.8	± 0.9
IV. Abscessus periappendicularis..	25	—	—	—
Total	313	3	1.0	± 0.6

Statistically the inguinal herniae following KROGIUS's incision appear incidental with the exception of operations at the peritonitis diffusa stage which seems symptomatic with regard to inguinal herniae.

Diagnosis	I	.....	$1.9 - 1.0 = +0.9 \pm 1.4$	$(0.6 \times 1.4 = 0.8)$
»	II	.....	$0.9 - 1.0 = -0.1 \pm 1.0$	$(0.1 \times 1.0 = 0.1)$
»	III	.....	$0.8 - 1.0 = -0.2 \pm 0.9$	$(0.2 \times 0.9 = 0.2)$
»	II}	.....	$0.9 - 1.0 = -0.1 \pm 0.6$	$(0.2 \times 0.6 = 0.1)$
»	III}	.....		

As to left inguinal herniae following operations included in my material these have occurred only in 0.38 per cent of the cases (GIERTZ 0.38 per cent, MAESSE 0.36 per cent). MCBURNEY's incision was never followed by left inguinal herniae. In two cases left inguinal herniae occurred after LENNANDER's and in two cases after KROGIUS's incision. In $\frac{3}{4}$ of the cases drainage lasted 5 days or longer. The average age of the patients who developed left inguinal herniae was 34 years and all were men.

As a summary of the aforesaid I consider myself entitled to draw the following conclusions:

According to LEHMANN the frequency of inguinal herniae is 2.1 — 2.8 per cent. Judging from this, inguinal herniae in my material might

have occurred even without the preceding appendectomy. I cannot thus maintain that appendectomy was definitely the decisive factor in the manifestation of inguinal herniae in my material. If, however, the operations for peritonitis diffusa universalis are treated separately these operations are followed by right inguinal herniae in 5.9 per cent of the cases operated through MCBURNEY's and in 5.1 per cent of LENNANDER's incision and the correlation coefficients can also be proved to belong to these groups of diagnoses. Therefore, *if the peritonitis has developed far and a long incision has been employed, and if further drainage was prolonged, right inguinal herniae may occur in a considerable number of persons who have a hereditary predisposition to herniation.* There is an evident conformity in the postoperative occurrence of inguinal and incisional herniae because, as proved in the foregoing, the frequency of incisional herniae also increases as the stage of the disease grows worse.

According to literature the reason for the occurrence of inguinal herniae after the use of MCBURNEY's incision is severing of the ilio-inguinal and the iliohypogastric nerves, and after the use of LENNANDER's incision general functional disturbances of the abdominal layers. In both these cases the general strain on the abdominal layers and the injury to them caused by the peritonitis are also of importance.

KROGIUS's incision does not seem to contribute towards manifestation of inguinal herniae.

If on the basis of my material the three appendectomy incisions dealt with in this investigation are compared as possible causes of right inguinal herniae, MCBURNEY's *incision seems more frequently to lead to manifestation of inguinal herniae than the other incisions.*

III.

THE RELATION OF MECHANICAL INTESTINAL DISTURBANCES TO AN EARLIER OPERATION FOR APPENDICITIS WITH PERITONITIS.

General Part.

Introduction.

The most serious of all postoperative complications are pains caused by adhesions and symptoms of early or late intestinal obstruction. The main part of the cases of early obstruction consists of cases of so-called dynamic paralytic ileus caused by bacterial toxins with ensuing paralysis of the peristaltic waves and the bloodvessels, a paralysis which frequently comprises the whole bowel. Paralytic ileus of a certain portion of the intestine and caused by abscesses etc. is sometimes referred to a group of its own (KROGIUS 1901, PETREN 1932) but belongs nevertheless to dynamic primary ileus. On the other hand the symptoms of intestinal obstruction in a distinctly limited portion of the intestine due to various mechanical reasons, are referred to as postoperative mechanical late ileus; the symptoms occur postoperatively after a free interval during which the movement of the bowel has been fairly normal. In its purest form mechanical ileus occurs months, or perhaps years after the operation.

According to BAUER the mechanical intestinal disturbances which occur already during the period of convalescence one or several weeks after the operation, are frequently not purely mechanical as by that time the original peritonitis is seldom healed

completely without leaving the smallest trace of paralysis. PETREN therefore prefers to speak only of mainly paralytic or mainly mechanical intestinal disturbances between which there are numerous forms of transition.

Etiology.

Postoperative mechanical intestinal disturbances have been much investigated from various points of view. It has been established that etiologically they are occasioned by the same factors as the intra-abdominal adhesions of various kinds on which most postoperative intestinal disturbances actually depend.

As early as in the eighteen sixties SPENCER WELLS and later many German gynecologists dealt with this question (LIFSCHITZ 1925). The same plasticity of the peritoneum which is of great assistance in abdominal surgery by limiting, for instance, the sequelae of a perforated ulcer ventriculi, appendix and gallbladder to the nearest surroundings of the viscera in question and which makes abdominal surgery possible, causes adhesions with ensuing terrible pains to the patient and serious problems to the physician in charge, after the original disease is already considered almost or even completely cured.

1. The development of intra-abdominal adhesions.

When the endothelial cells have been injured the serous surfaces in question are covered by fibrin and fairly soon regeneration of the cells sets in, beginning at the borders of the defect and the defect area is covered by a new layer of endothelium. But before this the fibrin-covered serous surface frequently adheres to the serosa of the nearest organ or to the peritoneal wall and an adhesion is formed. SÄNGER and REICHEL (1890) arrived at the result that every defect in the peritoneum results in the formation of adhesions whereas, according to DUSCHINSKY (1898), a simple peritoneal defect never leads to development of adhesions.

The injured serous surface may adhere to completely unaffected serous surfaces (SÄNGER) even though it prefers a defect area to which it becomes more rapidly attached. According to GRASER (1888) two injured surfaces must continuously be in touch with

one another before adhesions can develop. WERESCHINSKI (1915) established that the normal epithelium which covers sound tissue may prevent the development of adhesions, but that this capacity is relative inasmuch as even healthy endothelium may in the presence of an irritant take active part in adhesion formation. Thus irritation of a latent chronic inflammatory focus in the abdominal cavity may give rise to large fibro-serous membranes which cover various parts of the intestine.

The inflammatory exudate which fastens the viscera to one another, plays an important rôle in the development of adhesions particularly with the aid of its fibrinoblasts. The cells of the intra-abdominal adhesions originate from the serous and subserous tissue and from the cells of the walls of the bloodvessels. The regeneration of the connective tissue fibers commences in the subserosa of the viscera in the shape of precollagenic fibers which gradually change into collagenic fibers. WERESCHINSKI obtained this important information through his animal experiments and clinical investigations.

2. The rate of development of adhesions.

The time required before adhesions commence developing varies between a few minutes and some hours, according to FRITSCH (1890). It should be mentioned that vascularization commences already after about 24 hours, and arterial and venous capillaries may be noticed on the tenth day, arteries and veins on the 27th day (WERESCHINSKI).

3. The nature of the adhesions.

The adhesions found in the abdominal cavity are either surface adhesions, or thin membranous, cord-like or band-like adhesions with a thickness varying between that of a thread and a finger. They are either flat or round formations from a few cm. to 10 centimeters in length (KÖRTE, WERESCHINSKI). In the adhesions are bloodvessels and nerves as well as smooth and striated muscle fibers. According to GIRGOLAFF (1922) the discomfort of the patient depends on the nature of the nerves of the adhesions. LADWIG (1928), on the other hand, did not notice any nerves in the adhesions,

but explains that the pain is due to the irritation being conducted to the sympathetic nerve fibers when the adhered viscera stretch the radix mesenterii. The movements of the body and the diaphragm and the peristaltis of the intestine increase the irritation and thus the pain. — It should also be mentioned that a large part of the patients who have developed adhesions are unaware of this fact, as the adhesions only seldom cause any trouble. According to PETERMANN (1941) only 10 per cent of the adhesions cause pain to their bearers.

4. On factors influencing the development of adhesions.

Above all things a multitude of operative technical factors influence the development of adhesions. According to PAYR (1924) even the smallest injury to a serosa in connection with an operation may cause adhesion formation. The peritoneum is extremely sensitive particularly to foreign bodies. The least important chemical, mechanical, or heat irritant and even drying caused by air, may result in detachment of the endothelial cells, decomposition of their nuclei, and necrosis (BAISCH 1905, VOGEL 1922, PAYR 1924). According to WALTHARD (1893) exposure to air causes adhesions only when two serous surfaces are affected. Iodine used for disinfection of the skin may act as an irritant, and cause adhesion formation when it gets in touch with the serosa of the intestine (PROPPING 1911, GELLHORN 1928, PETERSON 1934). Peritoneal clamps, artery forceps, clips and ligatures may cause tissue necroses reaching deep into the subserosa.

Every interference which causes rough surfaces and injuries to the serosa is of evil. Non-peritonized ligation stumps (BUMM 1888) are dangerous as the intestine may adhere to them. Likewise the stump of a ligated omentum, having become attached to the intestine, may develop into a long cord-like or band-like formation. According to DEMBOWSKI (1888), ligated stumps are the most frequent reasons for the development of adhesions.

According to others the use of drainage and tamponage should be limited as far as possible in order not to stimulate adhesion formation by injuring the serosa of the intestine or deeper the intestinal walls or the peritoneum parietale (NAEGELI 1922, CRILE 1925, KRECKE 1926, TONENBERG 1928, BALDWIN 1930). If a drain

is applied, however, BALDWIN advises its introduction into the abdominal cavity by avoiding contact at any rate with the moving parts of the intestine.

BAUER states that drainage is a determining factor for the development both of local intestinal paralysis and of mechanical occlusion. A condition precedent for their occurrence is, in fact, a latent local inflammatory focus in the abdominal cavity after the peritonitis has otherwise healed. Residual abscesses, particularly Douglas's abscesses, are generally comparatively benign and do not cause complications. They are little apt to cause intestinal disturbances. But in drained cases the pelvic peritonitis often persists giving rise to adhesions, »Knickung»-formations in the intestine and accretion of the intestinal coils. According to BAUER drainage causes forms of intestinal occlusions in which mechanical factors dominate either alone or with paralysis.

STRAUCH (1926) on the other hand states that the danger of adhesions which is ascribed to drainage and tamponage is exaggerated, and he therefore approves of both these methods of drainage. NOETZEL and PROPPING (1927) defend drainage stating that the adhesions do not set out from the area of the drainage. However, practise and experience show their opinion to be wrong.

Local ulceration of the intestinal wall occurs in connection with far developed peritonitis, and as a result of the disease itself. If drainage or tamponage is applied the inflamed intestinal wall is still more easily injured, deep ulcers or even intestinal fistulae occur, the healing of which is followed by various intestinal disturbances.

SMITH & LAURIN (1934) among others, advise care to be taken not to cause chemical injuries in connection with various washings of the peritoneal cavity such as for instance ether. COFFEY (1913) and MARTIUS (1922) warn against the use of so-called »Gleitschmier» substances which were introduced into the abdominal cavity in order to prevent adhesion formation, and which (camphor oil) might even be followed by death. According to some investigators (i.a. BAISCH, COFFEY) there is no difference between wet and dry treatment, whereas SCHMID (1911) and PAYR (1913) state that wet treatment is less dangerous. Many surgeons such as, for instance, VOGEL (1922) and LÄWEN (1939) advise very cautious sponging.

As to the mechanical irritation of the peritoneum some authors have investigated it experimentally. Thus DEMBOWSKI for instance rubbed the peritoneum in connection with laparotomy with a tooth-brush and a renewed laparotomy showed no adhesions. In the same way VOGEL rubbed the peritoneum with a sponge and neither did he establish any adhesions. Thus a mechanical irritation need not always cause the development of adhesions.

The unfavourable location and the length of a laparotomy incision are, according to WIDERØE (1927) the most important causes of the adhesion formation, as also drains introduced into the abdominal cavity through the incision. According to WIDERØE's laparotomy statistics most of the adhesions occurred after a median or a pararectus incision whereas they were seldom found in the lower lateral portions of the abdomen. In all cases drained through the laparotomy wound, adhesions occurred in the wound.

The proportions were the same in TURUNEN's material (1933) which comprised largely undrained gynecological cases. There were considerably more adhesions after median incisions below the umbilicus than after appendectomy incisions in the right lower portion of the abdomen. According to TURUNEN the reasons for this are: 1) the anatomical structure of the abdominal wall due to which lateral wounds are more easily closed, 2) cases operated through median incisions are generally more serious than those operated through lateral incisions and therefore both the incision and the time necessary for the operation are longer and the possibilities of injury to the serosa greater. In TURUNEN's material adhesions also occurred in the laparotomy scar in all cases drained through the laparotomy wound, whereas adhesions were found only in 60 per cent of the cases primarily sutured.

The method of closing the peritoneum also influences the adhesion formation. In cases of appendectomy incisions TURUNEN found 11.1 per cent adhesions after sero-serous and 64.3 per cent after simple continuous sutures.

With regard to the suture material more adhesions are ascribed to the use of silk than to that of catgut (MONSON 1927 among others). The same applies also to the use of these suture materials as ligatures.

According to literature infection of the abdominal cavity

further adhesion formation in general, but PAYR (1924) established that the proteolytic ferment contained in pus may prevent adhesion formation or cause young fibrinous adhesions to become resorbed whereas the said ferment has no provable influence upon old fibrous adhesions.

The influence of infection on the formation of adhesions in the operation scar is, according to TURUNEN, unimportant. In his total material of relaparotomies adhesions occurred in the operative scar following infectious gynecological operations in 76.1 per cent of the cases and after aseptic operations in 71.1 per cent of the cases. Infection of the proper laparotomy wound did not, according to TURUNEN's observations, to any noticeable degree influence the adhesion formation.

Residual blood after an operation of the abdominal cavity is maintained to forward the formation of adhesions (BAISCH). FROMME (1906, 1907) made animal experiments in order to throw light upon this question. He opened the epigastric artery of rabbits. At laparotomy later performed on 35 rabbits he found no adhesions in 31 experimental animals, the blood apparently being resorbed in 6—10 days. Further 40 rabbits showed infections but no adhesions. On the basis of his experiments FROMME established that, besides residual blood, many other factors must be present to cause the development of adhesions. He found such factors to be serious infections, surfaces with an injured serosa and temporary paralysis of certain portions of the intestine. VOGEL, on the other hand, states that if the endothelium is intact there will be no coagulation and the blood will be resorbed.

Small mesenteric hematomata due to chronic obstipation may also occasion adhesions (PETERMANN 1941).

The movements of the intestine and the peristalsis, or the absence of these, play an important rôle in this connection. KÖRTE (1903), TURNER (1906), EKLUND (1908), VOGEL (1922) and MARTIUS (1922) among others have investigated these questions.

LIFSCHITZ drew attention to the circumstance that factors which caused a more or less marked adhesion formation in some patients caused no disturbances in others. According to LIFSCHITZ, BARTEL among others had already earlier noticed this fact, and assumed that also constitutional factors existed with

regard to the formation of adhesions. BARTEL performed pathologic-anatomic serial investigations on persons which he considered as belonging to the status thymicolymphaticus. In these persons the parenchyma of the lymphglands as well as of other organs was atrophied and there was a rich formation of connective tissue which he called connective tissue diathesis. According to LIFSCHITZ «Stiller's asthenic constitution» is closely related to this type. There is thus a rich formation of connective tissue in all these persons and adhesions develop readily.

LIFSCHITZ further stresses the circumstance that in the connective tissue the course of reaction occasioned by certain constitutional characteristics of the organism of forming adhesions even after the most trifling irritation, may sometimes cause diagnostic difficulties. The irritants which provoke those adhesions may be so insignificant that they cannot even be anamnesticly ascertained.

In FUNK's (1921) opinion these hypersensitive individuals should be operated upon only in extreme cases. PICCO (1940) and SABATTINI (1941) also consider constitutional factors of greater importance than the operative technic for the development of adhesions.

Since we cannot choose constitution efforts have been made to find other means of preventing the development of adhesions. Greater attention has lately been paid to circumstances of operation technique which further the formation of adhesions and by the improvement of which the frequency of adhesions may be reduced.

Adhesions do not frequently occur as a result of movements of the intestine and of the peristalsis even though predisposition is otherwise present. Surfaces with injured serosa do not touch one another long enough to allow the formation of adhesions, or if adhesions have developed between coils of intestine, or between other organs, they may be stretched, due to the movements of the intestine and to the peristalsis, to long cords or bands (EKLUND) and even rupture (TURUNEN). Due to these movements adhesions which have already developed may become resorbed (TURUNEN) or cause various kinds of volvulus, invagination etc.

Slow or absent peristalsis furthers adhesion formation. The fact that, for instance, cecal adhesions are the most common

laparotomy wound adhesions of the intestine after appendectomies, proves this statement. A further proof is that of all laparotomy adhesions those of the immobile omentum are the most common.

Thus, in the appendectomy cases investigated by TURUNEN most adhesions had developed through the omentum adhering to the laparotomy scar (45.2 per cent). The second largest group were adhesions of the cecum adhering to the scar (41.1 per cent). A portion of the large intestine and the small intestine developed adhesions in 5.5 per cent and the Fallopian tube adhered to the appendectomy stump in 2.7 per cent of the cases.

According to TURNER the peristalsis together with certain anatomical factors also determines the site on which adhesions best develop and persist, and also the spreading of the infection. According to him adhesions are frequently found in the lateral portions of the abdominal cavity, on the sigmoid flexure, above the liver, around the spleen and in the region of the last portion of the ileum, as this is the firmest fixed part of the small intestine and thus the least movable. ROTENBERG (1931) when investigating the topography of adhesions, also established that adhesions develop in quite definite places which were always identical after similar interferences.

Modes of Occurrence of Postoperative Mechanical Intestinal Disturbances.

I have in the foregoing elucidated the many factors which influence the formation of adhesions and also mechanical and intestinal disturbances. In the following I shall roughly deal with the former in which mechanical late complications or various intestinal disturbances occur.

The pain varies depending on the location of the adhesions. Some adhesions cause only a vague sense of pressure while others cause hard tearing pain. Characteristic of the pain caused by adhesions is that it can be felt only in certain positions of the body or in certain movements.

Strangulated ileus occurs as a result of cord-like or band-like adhesions constricting a portion or a bundle of the intestine thereby partly or totally compressing the intestinal lumen. Strangulation can also follow the occurrence of an aperture in a broad sheet of

adhesion into which a coil of intestine passes and becomes strangulated. If the adhesions are long and band-like they may form a loop and strangulate the intestine, generally in the area of the abdominal cavity. Short and inelastic formations generally cause occlusion by compressing a portion of the intestine under the adhesion. This is common in the pelvic region. An intestinal coil may also ride on a firm adhesion, the ends hanging down on each side and the lumen becoming constricted (KÖRTE). Such formations of adhesion may as I already mentioned stretch and finally rupture after which the symptoms of obstruction disappear.

Cases of late occlusion caused by strangulation are considered the most serious as the circulation of the blood in the strangulated portion of the intestine or the mesentery soon ceases.

Ileus occasioned by internal incarceration is due to the fact that during the operation pocket-like formations have occurred into which a coil of intestine has become jammed thereby causing occlusion (KÖRTE, BRUNN). If the hernial sac contains intestine, strangulation of the incisional hernia causes either a partial or a total occlusion.

Invaginations caused by adhesions are found in the ileocecal region (PAYR 1924).

Various kinds of volvulus may also occur as a result of adhesions. When helical adhesions occur volvulus, or so called »WILM's Wringverschluss«, may develop as the result of various factors such as, for instance, severe meteorism. The mechanism of origin of these intestinal and particularly cecal obstructions has been thoroughly investigated among others by the Finnish surgeons FALTIN (1902, 1904, 1909) and TIISALA (1918).

Intestinal obstruction may also follow adhesions or mesenteric contractions which draw the bases of the intestinal coils closer together (EKLUND 1906, SÅLTIN 1909).

Obturation may be caused by co-operation of operative technical and infectious factors. If in connection with an operation the intestinal wall is injured in one way or another (drainage, for instance), shrinkage due to cicatricial tissue may later occur in the injured spot and may sometimes reach as far as around the intestine. A shrinking scar of this kind may, depending on its size, cause obturations of various degrees.

In the same way an enterostomy opening occasioned by paralytic ileus following peritonitis, may bring about compression of the intestinal lumen when cicatrizing.

Postoperative late obturation may also be due to the intestine adhering for instance to an amputated or ligated stump in which case a sharp intestinal bend may be formed (Abknickung) which allows the intestinal contents to pass only partly or not at all. Severe meteorism in this spot may give rise to a so-called closing valve which by a continued peristalsis frequently causes the valvular intestinal portion to turn around its axis forming a volvulus as described in the foregoing (WILM's Wringverschluss).

Abknickung-formations may result from shrinking of the mesentery caused by a healed inflammation.

Postoperative adhesions may cause motility disturbances in the intestine or part of it, which may lead to chronic obstipation and even to the formation of fecal stones (KLEINSCHMIDT & HOHLBAUM 1941). Thus, for instance, the omentum, when adhering to the operative scar, may draw the transverse colon down at an angle so that the intestinal contents pass the flexures only partly or not at all (Transversoptose) resulting in symptoms of either partial or total occlusion (PAYR 1920). In TURUNEN's material of 82 appendectomies there were 3 cases of this kind.

1. *The interval after which postoperative mechanical intestinal disturbances occur.*

The interval after which postoperative mechanical intestinal disturbances occur varies greatly, according to my investigations. TURNER established that after operations for appendicitis mechanical intestinal disturbances occurred within 2—25 days. CARLSON & MARSHALL (1926) state that these disturbances manifest themselves within 2—18 days after the operation. BAUER on the other hand has observed that they commence as early as 5—8—12 days after the operation but that they may also occur after several months and even years. ADY (1938) found that ileus generally occurs on the 2nd, 3rd, 5th, or 7th day after the operation. According to CHARRIER & LANGE (1939) postoperative ileus appears mostly on the 5th or 6th day after the operation, and according to PICCO (1940) on the 6th or 7th day.

It should be stated, however, that many of the aforesaid intervals are far too short to diagnose pure mechanical intestinal obstructions. A few days or a week after the operation for peritonitis is not enough to allow one to leave paralytic ileus out of consideration. Actual mechanical ileus does not occur, according to BAUER, until months or years after the operation.

2. The frequency of postoperative mechanical intestinal disturbances according to literature.

Publications and investigations on this subject are founded on the most varied viewpoints dealing with postoperative conditions of operations performed on various indications in a wider or more limited sense, and they cannot therefore be compared. Thus, for instance, it is difficult to determine the frequency of mechanical ileus occurring in connection with appendicitis as a considerable number of these cases do not become manifest until months or years after the patient has recovered from the appendicitis. It is also difficult to determine the frequency of postoperative mechanical intestinal disturbances because the patients are often admitted for operation to hospitals other than those at which appendectomy was originally performed. In order to elucidate the problem, however, I shall in the following mention the results of various authors.

SONNENBERG (1903) found 3 cases of intestinal occlusion developing gradually after appendicitis with peritonitis and 6 cases following appendicitis operated in the quiescent stage, without any simultaneous symptoms of peritonitis. The occlusion was caused both by strangulation and obturation and sometimes an axial twist was present.

TURNER (1906) states that after 2 500 appendectomies performed at various stages of the disease intestinal obstruction occurred in one case out of 153, out of 2 500 patients 23 (0.92 per cent) had occlusion mostly due to adhesions of the pelvic floor or to abscess contraction.

EKLUND (1908) collected his material from the years 1897—1907 and found 20 cases or 2.03 per cent of mechanical ileus out of 985 appendectomies of different kinds.

patients (0.89 per cent). 81 per cent of these patients were men and 19 per cent women. Almost one half of the cases were cases of strangulation occurring in the region of the lowest ileum.

When operation had been performed within 24 hours from the onset of the symptoms, postoperative ileus occurred only in 16 per cent of the cases whereas when the operation was performed within the first 48 hours ileus occurred in 54 per cent of the cases.

CHARRIER & LANGE observed during 13 years in 1 300 cases operated for acute appendicitis a total of 13 (1 per cent) cases of postoperative ileus occurring on the 6th—7th day.

Of the patients of CLAIRMONT's & MEYER's (1929) material on whom relaparotomy was performed because of ileus, 47.7 per cent were primarily operated for acute appendicitis or for peritonitis following appendicitis, whereas there were disturbances due to adhesions only in 2.6 per cent of the cases operated for the mentioned reasons. Adhesions occurred in 34.5 per cent of the cases operated for chronic appendicitis.

According to the statistics of appendectomies collected from literature by TURUNEN, the frequency of mechanical intestinal obstruction varied between 1.01—1.97 per cent.

In the foregoing I have described the disturbances which may be caused by intra-abdominal adhesions. Finally I wish to mention a case described in literature by FAVRE (1895) in which the adhesions which followed an operation for appendicitis, cured the patient (a married woman of 40 years) of a right inguinal hernia from which she had suffered for ten years. The hernial sac evidently adhered not allowing the hernia to protrude further, although the orifice still allowed the introduction of two fingers.

Clinical Part.

Introduction and Presentation of the Problem.

In the foregoing I have described the factors which lead to postoperative mechanical intestinal disturbances, and the mode of occurrence and form of appearance of these disturbances. I have also presented in figures the frequency of these same disturbances.

Owing to the character of my material conclusions with regard to adhesions and intestinal obstructions can be drawn only within very restricted limits. Symptoms resembling those of either complete or partial intestinal obstruction may often be due to quite other reasons. Thus, for instance, nephrolithiasis, cholelithiasis and torsion of intra-abdominal viscera may by a reflex act cause an intestinal condition which resembles mechanical intestinal obstruction. According to PETERSON (1934) statistics of occlusions should therefore be based only on such cases on which either laparotomy or obduction has been performed. In my material I have consequently dealt separately with the confirmed cases in which operation was performed because of intestinal obstruction, but in the general statistics I have also included all cases with pains of suspected adhesion or attacks passing either spontaneously or after lavage and indicating partial or total intestinal obstruction.

It should be mentioned that the patients included in my material had been discharged from the hospital at least three years before the time of my after-inquiry.

It is extremely difficult to investigate this subject on the basis of after-inquiries only, and the reliability of the result is doubtful. However, most of the patients have replied so carefully to the questionnaires (p. 59) that I have been able with a fair amount of certainty to determine when a patient suffered from attacks of either partial or total intestinal obstruction. Most of the patients who have had symptoms of intestinal obstruction, have had several attacks of pain together with borborygmus, nausea or vomiting, and during the attacks air did not pass through the rectum. It was in many cases necessary to call a physician who diagnosed a partial or complete intestinal obstruction. Some attacks have passed spontaneously or after lavage. There are also cases in which the first attack was due to complete intestinal obstruction which could only be operatively relieved, or such in which the attacks of pain were slight at first, becoming gradually more severe and leading finally to complete obstruction.

On the basis of replies received from the patients and of the corresponding records I have tried to elucidate the problem by four questions mainly dealing with intestinal obstruction and which appear from the following:

1) What is the frequency in my material of mechanical intestinal disturbances following operations for appendicitis through different incisions?

2) Was the occurrence of postoperative mechanical intestinal disturbances in any way influenced by the fact that operation was performed at a certain stage of the disease and is there any difference in this respect between the various incisions.

3) Was the fact of the time at which appendectomy was performed after the onset of symptoms of any importance for the occurrence of postoperative mechanical intestinal disturbances and is there any difference in this respect between the various incisions.

4) Did the length of the period of drainage influence the occurrence of postoperative mechanical intestinal disturbances? Is there in this respect any difference between the various incisions?

The Frequency of Mechanical Intestinal Disturbances Following Appendectomy.

1. The frequency of mechanical intestinal disturbances in the material of the different hospitals.

When I made my after-inquiries on the basis of the material from the Viipuri County Hospital (the years 1913—1932) in 1935 the patients had left the hospital after appendectomy between 3 and 22 years earlier. Out of the 576 patients who replied, 36 (6.25 per cent) had suffered from mechanical intestinal disturbances and complete occlusion which had to be operated, occurred in 5 (0.86 per cent) of these cases.

I made after-inquiries on the basis of the material from the Surgical Clinic of the University of Helsinki (the years 1915—1932) in 1937 and the patients had thus been discharged from the hospital between 5 and 20 years previously. Mechanical intestinal disturbances which all passed without operation, occurred in 5 patients (2.70 per cent) out of 185.

In 1937 and 1938 I sent questionnaires to the patients of the Maria City Hospital (the years 1905—1932). These patients had then been out of the hospital between 5 and 32 years. 8 (2.65 per

cent) out of 301 patients suffered from mechanical intestinal disturbances and two out of these (0.66 per cent) had complete occlusion which was operated.

When comparing the number of cases with symptoms indicating mechanical intestinal disturbances following appendectomy in the different hospitals, I found that the frequency of these cases was about the same (2.70—2.65 per cent) for the Surgical Clinic and the Maria City Hospital, the corresponding percentage for the material from the Viipuri County Hospital being 6.25. It is difficult to state the reason for the higher percentage of intestinal obstruction of the latter hospital. It might possibly, at least to some extent, be due to washing of the peritoneal cavity in connection with the operation. As far as I know washing was not at all performed at the Surgical Clinic, nor to any great extent in operations for appendicitis with peritonitis at the Maria City Hospital during the period which my material covers. Although physiological saline solution was used for washings they were found to irritate the peritoneum. Another factor might have been the operative technique. It is a well-known fact that late complications can to a great extent be avoided through good operative technique. All these hospitals are clinics at which 'candidates' of medicine and young surgeons perform their very first operations, mainly appendectomies. It may be that the candidates at the Viipuri County Hospital were allowed to operate after a shorter period of training than those of the other two hospitals in question, due to the large number of daily operations at the Viipuri County Hospital.

It should be mentioned in this connection that not even nearly as great attention is paid to the peritonization of the stump of the mesoappendix in general surgical clinics as in gynecological clinics. The high percentage of intestinal disturbances in my material was perhaps due to these stumps and to the peritoneal suture which in many cases, perhaps even in the majority was not seroseros but only a so-called simple continuous suture. I could not in my statistics consider the nature of the ligature and suture material, nor the circumstance whether the stumps were peritonized or not, as the records were incomplete in this respect.

TABLE 43. The relation of the stage of development of the disease to the occurrence of mechanical intestinal disturbances.

Diagnosis	Number of operations	Number of cases of mechanical intestinal disturbances	Percentage of intestinal disturbances	Percentage of mean error ε (p)
I. Appendicitis acuta non perforata	199	10	5.0	± 1.5
II. Appendicitis acuta perforata et peritonitis diffusa incipiens	366	18	4.9	± 1.1
III. Appendicitis acuta perforata et peritonitis diffusa universalis	414	18	4.8	± 1.1
IV. Abscessus periappendicularis..	83	3	3.6	± 2.3
Total	1 062	49	4.6	± 0.7

2. The frequency of mechanical intestinal disturbances in the total material.

On examining table 43 we find that out of 1 062 patients 49 (4.6 per cent) suffered from symptoms of either partial or total intestinal obstruction or from pains of suspected adhesion.

Out of these 7 (0.7 per cent) were cases of complete occlusion cured only through operation (table 44). In a diagnostic sense they belonged at the time of the first operation to the groups indicated in table 45 and their distribution in relation to the incisions appears from the same table.

TABLE 44. The frequency of total occlusion.

Diagnosis	Number of operations	Number of cases operated for total occlusion	Percentage of occlusions	Percentage of mean error ε (p)
I. Appendicitis acuta non perforata	199	2	1.0	± 0.6
II. Appendicitis acuta perforata et peritonitis diffusa incipiens	366	2	0.5	± 0.4
III. Appendicitis acuta perforata et peritonitis diffusa universalis	414	2	0.5	± 0.4
IV. Abscessus periappendicularis..	83	1	1.2	± 0.9
Total	1 062	7	0.7	± 0.3

TABLE 45. The distribution of cases of total occlusion in relation to different incisions and stages of development of the disease.

Incision	Appendicitis acuta non perforata	Appendicitis acuta per- forata et peritonitis diffusa incipiens	Appendicitis acuta per- forata et peritonitis diffusa universalis	Abscessus periappen- dicularis	Total
McBURNEY'S	—	—	—	1	1
LENNANDER'S	1	2	1	—	4
KROGIUS'S	1	—	1	—	2
Total	2	2	2	1	7

3. *The frequency of mechanical intestinal disturbances following different appendectomy incisions.*

When comparing the frequency of intestinal disturbances after different incisions as a whole (table 46) we shall find that there is less tendency to occlusion after McBURNEY'S (4.0 per cent) and KROGIUS'S (2.6 per cent) incisions than after LENNANDER'S incision (6.7 per cent).

TABLE 46. The frequency of mechanical intestinal disturbances following different appendectomy incisions.

Incision	Number of operations	Number of mechanical intestinal disturbances	Percentage of mechanical intestinal disturbances	Percentage of mean error ε (p)
McBURNEY'S	348	14	4.0	± 1.1
LENNANDER'S	401	27	6.7	± 1.1
KROGIUS'S	313	8	2.6	± 1.2
Total	1 062	49	4.6	± 0.7

WILMS (1906) established in his investigation that postoperative intestinal obstruction was more common in the drained cases in which the incision was situated in the middle line than in those with lateral incisions. GIERTZ (1909), WIDERØE (1927) and TURUNEN (1933) arrived at the same result. In my material there should thus be fewer cases of obstruction among the cases operated through

McBURNIEY'S incision than among those operated through KROGIUS'S incision. However, the circumstance is the reverse, although the difference between these groups is not great.

The Frequency of Mechanical Intestinal Disturbances Following Appendectomy Performed at Different Stages of the Disease.

1. The frequency of mechanical intestinal disturbances following appendectomy performed at different stages of the disease in general.

It appears from table 43 (p. 129) that the distribution of mechanical intestinal disturbances at the different stages of the disease does not vary much. There is about the same frequency of disturbances in cases operated at the non-perforated acute stage, as in those in which operation was performed at any of the peritonitis stages II—IV. *Neither can it be established within the range of this material whether intestinal disturbances depend on the stage of the disease at which operation was performed:*

Diagnosis	I	....	$5.0 - 4.6 = +0.4 \pm 1.5$	$(0.3 \times 1.5 = 0.5)$
»	II-III	....	$4.6 - 4.6 = \pm 0$	
»	IV	....	$3.6 - 4.6 = -1.0 \pm 2.3$	$(0.4 \times 2.3 = 0.9)$

Examining table 44 (p. 129) which comprises confirmed cases of complete occlusion which had to be operated, we shall find no large differences between the various groups of diagnoses in the tendency to occlusion. The highest frequency, 1.2 per cent, is found in cases operated at the abscess stage which is in conformity with similar information in literature. A periappendicular abscess is a local inflammatory focus in the abdominal cavity and various portions of the intestine take part in localizing the infection, resulting in all kinds of different adhesions and Abknickung-possibilities. After a radical operation the adhesions may partly disappear and the intestinal coils may stretch, but adhesions of long duration may also persist and become organized. WOLFF, for instance, finds in these cases 4.4 per cent of mechanical late intestinal obstruction.

According to PAYR'S investigation (1924) there is less mechanical

intestinal disturbances in the group of diffuse peritonitis than in other groups as, according to PAYR, there is in cases of severe purulent peritonitis a large amount of proteolytic ferment in the exudate which liquefies fibrin and the young connective tissue making them suitable for resorption. It appears from table 44 that the percentage of occlusions in the group of diffuse peritonitis (II-III) is by 0.5—0.7 per cent lower than that of the other groups (I & IV). However, due to the smallness of the material no absolute conclusions can be statistically drawn from this, as appears from the following expressions:

Diagnosis	I	....	$1.0 - 0.7 = +0.3 \pm 0.6$	$(0.5 \times 0.6 = 0.3)$
»	II-III	....	$0.5 - 0.7 = -0.2 \pm 0.3$	$(0.7 \times 0.3 = 0.2)$
»	IV	....	$1.2 - 0.7 = +0.5 \pm 0.9$	$(0.6 \times 0.9 = 0.5)$

2. The frequency of mechanical intestinal disturbances following appendectomies performed through the various incisions at different stages of the disease.

Examining the distribution of mechanical intestinal disturbances according to the stage of the disease in the different groups of incisions (tables 47, 48 and 49) we find that no absolute conclusions can be drawn. The highest tendency to intestinal disturbances is

TABLE 47. The relation between the stage of the disease and the postoperative mechanical intestinal disturbances in cases operated through McBURNEY'S incision.

Diagnosis	Number of operations	Number of cases of mechanical intestinal disturbances	Percentage of intestinal disturbances	Percentage of mean error ϵ (p)
I. Appendicitis acuta non perforata	63	4	6.7	± 2.5
II. Appendicitis acuta perforata et peritonitis diffusa incipiens	104	2	1.9	± 2.0
III. Appendicitis acuta perforata et peritonitis diffusa universalis	152	7	4.6	± 1.6
IV. Abscessus periappendicularis..	29	1	3.4	± 3.6
Total	348	14	4.0	± 1.0

TABLE 48. The relation between the stage of the disease and the post-operative mechanical intestinal disturbances in cases operated through LENNANDER'S incision.

Diagnosis	Number of operations	Number of cases of mechanical intestinal disturbances	Percentage of intestinal disturbances	Percentage of mean error ϵ (p)
I. Appendicitis acuta non perforata	83	4	4.8	± 2.8
II. Appendicitis acuta perforata et peritonitis diffusa incipiens	153	14	9.1	± 2.0
III. Appendicitis acuta perforata et peritonitis diffusa universalis	136	8	5.9	± 2.1
IV. Abscessus periappendicularis..	29	1	3.4	± 4.5
Total	401	27	6.7	± 1.3

TABLE 49. The relation between the stage of the disease and the post-operative mechanical intestinal disturbances in cases operated through KROGIUS'S incision.

Diagnosis	Number of operations	Number of cases of mechanical intestinal disturbances	Percentage of intestinal disturbances	Percentage of mean error ϵ (p)
I. Appendicitis acuta non perforata	53	2	3.8	± 2.3
II. Appendicitis acuta perforata et peritonitis diffusa incipiens	109	2	1.8	± 1.5
III. Appendicitis acuta perforata et peritonitis diffusa universalis	126	3	2.4	± 1.4
IV. Abscessus periappendicularis..	25	1	4.0	± 2.9
Total	313	8	2.6	± 0.9

found in cases operated through MCBURNEY'S incision in the acute stage, and in the cases operated through LENNANDER'S incision in the peritonitis diffusa stage, nor is there in any other respect conformity between the percentages of these statistics. Intestinal disturbances occurred in 3.4—4 per cent (WOLFF 4.4 per cent) of the cases operated at the abscess stage.

Owing to the smallness of the material it cannot even be statistically determined in the cases of different appendectomy incisions whether the adhesion pains and the symptoms of intestinal obstruction depend on the stage of the disease or not. *It does seem, however, as if the stage of the disease at which operation was performed, were of no particular importance to the occurrence of post-operative mechanical intestinal disturbances.*

McBURNEY'S incision:

Diagnosis	I	....	$6.7 - 4.0 = +2.7 \pm 2.5$	$(1.1 \times 2.5 = 2.8)$
»	II-III	....	$3.5 - 4.0 = -0.5 \pm 1.2$	$(0.4 \times 1.2 = 0.5)$
»	IV	....	$3.4 - 4.0 = -0.6 \pm 3.6$	$(0.2 \times 3.6 = 0.7)$

LENNANDER'S incision:

Diagnosis	I	....	$4.8 - 6.7 = -1.9 \pm 2.8$	$(0.7 \times 2.8 = 2.0)$
»	II-III	....	$7.6 - 6.7 = +0.9 \pm 1.4$	$(0.6 \times 1.4 = 0.8)$
»	IV	....	$3.4 - 6.7 = -3.3 \pm 4.5$	$(0.7 \times 4.5 = 3.2)$

KROGIUS'S incision:

Diagnosis	I	....	$3.8 - 2.6 = +1.2 \pm 2.3$	$(0.5 \times 2.3 = 1.2)$
»	II-III	....	$2.1 - 2.6 = -0.5 \pm 1.0$	$(0.5 \times 1.0 = 0.5)$
»	IV	....	$4.0 - 2.6 = +1.4 \pm 2.9$	$(0.5 \times 2.9 = 1.5)$

The Frequency of Mechanical Intestinal Disturbances Following Appendectomy Performed on Different Days of the Disease.

1. The frequency of mechanical intestinal disturbances following appendectomy performed on different days of the disease in general.

According to literature the tendency to mechanical intestinal disturbances increases when the interval between the onset of the disease and the operation is prolonged. I have already mentioned ADY'S appendectomy statistics (p. 124) which comprise all, — thus also the early — cases of postoperative occlusion according to which occlusion occurred in 10 per cent of the cases operated within 24 hours after the onset of the disease, whereas the percent-

age was 54 in cases operated within 48 hours after the onset of symptoms. The relation of the tendency to postoperative occlusion in cases operated on the first and second day of illness respectively, was 1:5.4. However, literature also mentions that the rate of development of the disease varies in different cases. As already explained (p. 82) the clinical and pathologic-anatomical pictures do not always correspond, as the clinical symptoms often appear much later than the pathologic-anatomical changes caused by the disease. Thus appendicitis in some cases leads to perforation already within a few hours, in others only after several days of illness.

As it seems probable on the basis of the foregoing chapter that the frequency of mechanical intestinal disturbances is not to any notable degree influenced by the circumstance that operation is performed at a certain stage of the disease, there ought to be no difference in this respect with regard to the day after the onset of the symptoms on which operation was performed. Whether this is true with regard to my material appears from the tables 50 and 51.

It appears from table 50 which comprises my total material grouped on the basis of the interval between the onset of symptoms and the appendectomy regardless of the operative diagnosis, that the occurrence of late intestinal disturbances was not to any notable degree influenced by the point of time of the operation. The majority of the mechanical intestinal disturbances certainly occurred in cases operated within two days from the onset of the

TABLE 50. The relation of the day of operation to the occurrence of mechanical intestinal disturbances.

Operated not later than	Number of operations	Number of cases of mechanical intestinal disturbances	Percentage of intestinal disturbances	Percentage of mean error ε (p)
24 hours after the first symptoms ..	282	12	4.3	± 1.3
48 " " " " " ..	395	20	5.1	± 1.1
72 " " " " " ..	175	9	5.1	± 1.6
more than 72 hours after the first symptoms	210	8	3.8	± 1.5
Total	1 062	49	4.6	± 0.7

TABLE 51. The relation of the day of operation to the occurrence of complete occlusion.

Operated not later than	Number of operations	Number of operated cases of total occlusion	Percentage of occlusions	Percentage of mean error ε (p)
24 hours after the first symptoms ..	282	1 } 2	0.4	± 0.5
48 » » » » » ..	395		0.3	± 0.4
72 » » » » » ..	175	3 } 5	1.7	± 0.6
more than 72 hours after the first symptoms	210		1.0	± 0.6
Total	1 062	7	0.7	± 0.3

disease, but most of the patients included in my total material were operated within two days from the onset of symptoms. In order to be able to draw a conclusion with regard to the relation of the day of operation to the occurrence of late intestinal disturbances, the frequency of mechanical intestinal disturbances must be determined according to the point of time of the operation. We shall find that operations performed during the second day of illness are followed by a somewhat greater tendency (4.7 per cent) to mechanical intestinal disturbances than operations performed later (4.4 per cent). Statistically these groups are, however, almost equal:

Cases operated within

$$48 \text{ hours} \quad \dots \quad 4.7 - 4.6 = +0.1 \pm 0.8 \quad (0.12 \times 0.8 = 0.1)$$

$$\text{Cases operated later} \dots 4.4 - 4.6 = -0.2 \pm 1.1 \quad (0.2 \times 1.1 = 0.2)$$

2. The dependance of complete occlusion on the day of operation.

On examining separately the dependance of complete occlusion on the point of time of operation (table 51) we find that *the tendency to occlusion seems to increase if the interval between the onset of the disease and the operation is prolonged*. Symptoms of occlusion occur in 0.3 per cent of the cases operated during the first two days and in 1.3 per cent of patients operated later. The relation of the tendency to occlusion after operations performed at an early and a late stage of the disease is thus 1:4.3. It is also statistically

possible that the tendency to occlusion increases as the interval between the onset of the disease and the operation is prolonged:

Cases operated within

48 hours $0.3 - 0.7 = -0.4 \pm 0.3$ ($1.2 \times 0.3 = 0.4$)

Cases operated later .. $1.3 - 0.7 = +0.6 \pm 0.4$ ($1.5 \times 0.4 = 0.6$)

3. *The relation between the day of the operation and mechanical intestinal disturbances in cases of different incisions.*

Investigations on the relation of the day of the operation to the occurrence of mechanical intestinal disturbances separately for cases operated through different incisions (tables 52-54) show

TABLE 52. The relation of the day of operation to mechanical intestinal disturbances in cases operated through MCBURNEY'S incision.

Operated not later than	Number of operations	Number of cases of intestinal disturbances	Percentage of intestinal disturbances	Percentage of mean error ε (p)
24 hours after the first symptoms..	97	3	3.1	± 1.3
48 » » » » ..	139	5	3.5	
72 » » » » ..	51	3	5.9	± 1.9
more than 72 hours after the first symptoms	61	3	4.9	
Total	348	14	4.0	± 1.0

TABLE 53. The relation of the day of operation to mechanical intestinal disturbances in cases operated through LENNANDER'S incision.

Operated not later than	Number of operations	Number of cases of intestinal disturbances	Percentage of intestinal disturbances	Percentage of mean error ε (p)
24 hours after the first symptoms..	100	6	6.0	± 1.6
48 » » » » ..	147	12	8.2	
72 » » » » ..	74	5	6.8	± 2.0
more than 72 hours after the first symptoms	80	4	5.0	
Total	401	27	6.7	± 1.3

TABLE 54. The relation of the day of operation to mechanical intestinal disturbances in cases operated through KROGIUS's incision.

Operated not later than	Number of operations	Number of cases of intestinal disturbances	Percentage of intestinal disturbances	Percentage of mean error ε (p)
24 hours after the first symptoms ..	85	3	3.5	± 1.2
48 » » » » » » ..	109	3	2.8	
72 » » » » » » ..	50	1	2.0	± 1.5
more than 72 hours after the first symptoms	69	1	1.4	
Total	313	8	2.6	± 0.9

that in cases of MCBURNEY's incision (table 52) the frequency of intestinal disturbances increases if the interval between the onset of the disease and the operation is prolonged, whereas the circumstance is reversed in cases of LENNANDER's and KROGIUS's incisions (tables 53 and 54). On the basis of my material no absolute conclusions can be drawn statistically as to the relation between the day of operation and the frequency of intestinal disturbances in cases of different incisions, as appears from the following expressions:

MCBURNEY's incision

Cases operated within

$$48 \text{ hours} \dots\dots\dots 3.4 - 4.0 = -0.6 \pm 1.3 \quad (0.5 \times 1.3 = 0.7)$$

$$\text{Cases operated later} \dots\dots\dots 5.4 - 4.0 = +2.4 \pm 1.9 \quad (1.3 \times 1.9 = 2.5)$$

LENNANDER's incision

Cases operated within

$$48 \text{ hours} \dots\dots\dots 7.3 - 6.7 = +0.6 \pm 1.6 \quad (0.4 \times 1.6 = 0.6)$$

$$\text{Cases operated later} \dots\dots\dots 5.9 - 6.7 = -0.8 \pm 2.0 \quad (0.4 \times 2.0 = 0.8)$$

KROGIUS's incision

Cases operated within

$$48 \text{ hours} \dots\dots\dots 3.1 - 2.6 = +0.5 \pm 1.2 \quad (0.4 \times 1.2 = 0.5)$$

$$\text{Cases operated later} \dots\dots\dots 1.7 - 2.6 = -0.9 \pm 1.5 \quad (0.6 \times 1.5 = 0.9)$$

Summary. On the basis of my material we cannot state that the day of operation has any noticeable influence on the occurrence of late mechanical intestinal disturbances. As the stage of development of the disease neither was of any importance in this respect, the reason for possible differences must be sought in other factors which may cause mechanical intestinal disturbances such as, for instance, operative technical factors, drainage, constitution etc. The tendency to complete occlusion may, however, to some extent depend also on the day of the operation.

My material does not prove with statistical certainty the existence of any relation between the day of operation and mechanical intestinal disturbances in general nor with regard to the different appendectomy incisions.

The Relation of the Duration of Drainage to the Frequency of Mechanical Intestinal Disturbances.

1. The relation of the duration of drainage to the frequency of mechanical intestinal disturbances in general.

TABLE 55. The relation of the duration of drainage to the frequency of mechanical intestinal disturbances.

Maximum lapse of time between operation and removal of drain	Number of operations	Number of cases of intestinal disturbances	Percentage of intestinal disturbances	Percentage of mean error ϵ (p)
24 hours	75	1	1.3	± 2.4
48 »	141	1	0.7	± 1.8
72 »	149	5	3.5	± 1.7
5 days	207	19	9.2	± 1.5
7 » or more..	490	23	4.7	± 0.9
Total	1 062	49	4.6	± 0.7

We shall find from table 55 that *the mechanical intestinal disturbances increase as the period of drainage is prolonged*. 89 per cent (42) of all mechanical intestinal disturbances (49) occurred in cases in which the drain was removed later than 3 days after the operation. The reason is presumably the fact that the drain, being a foreign

body, irritates the peritoneum, the serosa of the intestine and the omentum in direct relation to the duration of time that it remains in the abdominal cavity thereby causing firmer and more widespread adhesions. In this connection I refer to the chapter dealing with drainage (p.40). When the drain was removed within 3 days after the operation, intestinal disturbances occurred only in 1.9 per cent of the cases whereas they occur in 6.0 per cent of the patients from whom the drain was removed later, viz. three times more frequently than in the former group. *It seems also statistically almost certain that the tendency to mechanical intestinal disturbances increases as the period of drainage is prolonged:*

$$1.9 - 4.6 = -2.7 \pm 1.1 \quad (2.5 \times 1.1 = 2.8)$$

$$6.0 - 4.6 = +1.4 \pm 0.8 \quad (1.8 \times 0.8 = 1.4)$$

TABLE 56. The relation of the duration of drainage to the occurrence of occlusion.

Maximum lapse of time between operation and removal of drain	Number of operations	Number of cases of intestinal disturbances	Percentage of intestinal disturbances	Percentage of mean error ϵ (p)
24 hours	75	—	—	—
48 »	141	—	—	—
72 »	149	—	—	—
5 days	207	3 } ₇	1.4 } _{0.6}	± 0.6 } _{± 0.3}
7 » or more..	490			
Total	1 062	7	0.7	± 0.3

In all cases of operated total occlusion in my material (0.7 per cent, table 56) the drain remained in the abdominal cavity for more than 3 days. Thus, *if the drain was removed within the first three days after the operation, there were no cases of complete occlusion later*, which, in my opinion, is an evident proof of the irritating influence of the drain.

As an example of mechanical irritation caused by a drain I wish to mention, for the sake of completeness, 6 cases (0.6 per cent) of stercoral fistulae in my material. All fistulae occurred after operations in the diffuse peritonitis stage. The duration of drainage was in 3 cases more than 7 days, in 2 cases 5 days and in 1 case

3 days. NEWTON (1939) investigated drainage in cases of operated acute appendicitis, and found stercoral fistulae in 3.4 per cent of the drained cases and in 0.3 per cent of the undrained cases.

2. The relation between the duration of drainage and mechanical intestinal disturbances in cases operated through different incisions.

Examining the tables 57—59 we find that *the frequency of intestinal disturbances increases also in cases of different incisions as the period of drainage is prolonged*. The increase in the frequency is largest in cases operated through KROGIUS's incision (4.4 per cent), second largest in cases of LENNANDER's incision (3.4 per

TABLE 57. The relation of the duration of drainage to the occurrence of mechanical intestinal disturbances in cases operated through MCBURNEY's incision.

Maximum lapse of time between operation and removal of drain	Number of operations	Number of cases of intestinal disturbances	Percentage of intestinal disturbances	Percentage of mean error ε (p)
24 hours	15	—	} 3.4	± 2.1
48 »	29	—		
72 »	44	3		
5 days	58	2	} 4.2	± 1.2
7 » or more..	202	9		
Total	348	14	4.0	± 1.0

TABLE 58. The relation of the duration of drainage to the occurrence of mechanical intestinal disturbances in cases operated through LENNANDER's incision.

Maximum lapse of time between operation and removal of drain	Number of operations	Number of cases of intestinal disturbances	Percentage of intestinal disturbances	Percentage of mean error ε (p)
24 hours	7	—	} 2.2	± 2.6
48 »	41	—		
72 »	41	2		
5 days	92	12	} 8.0	± 1.4
7 » or more..	220	13		
Total	401	27	6.7	± 1.3

TABLE 59. The relation of the duration of drainage to the occurrence of mechanical intestinal disturbances in cases operated through KROGIUS's incision.

Maximum lapse of time between operation and removal of drain	Number of operations	Number of cases of intestinal disturbances	Percentage of intestinal disturbances	Percentage of mean error ε (p)
24 hours	53	1		
48 »	71	1		± 1.2
72 »	64	2	1.1	
5 days	57	5	4.8	± 1.4
7 » or more..	68	1		
Total	313	8	2.6	± 0.9

cent) and lowest in cases of MCBURNEY's incision (1.2 per cent). We cannot, however, determine this matter statistically on the basis of my material, as appears from the following expressions:

$$\begin{array}{lcl}
 \text{MCBURNEY'S incision} & \left\{ \begin{array}{l} 3.4 - 4.0 = -0.6 \pm 2.1 \quad (0.3 \times 2.1 = 0.6) \\ 4.2 - 4.0 = +0.2 \pm 1.2 \quad (0.2 \times 1.2 = 0.2) \end{array} \right. \\
 \text{LENNANDER'S } \gg & \left\{ \begin{array}{l} 2.2 - 6.7 = -4.5 \pm 2.6 \quad (1.7 \times 2.6 = 4.4) \\ 8.0 - 6.7 = +1.3 \pm 1.4 \quad (0.9 \times 1.4 = 1.3) \end{array} \right. \\
 \text{KROGIUS'S } \gg & \left\{ \begin{array}{l} 1.1 - 2.6 = -1.5 \pm 1.2 \quad (1.3 \times 1.2 = 1.6) \\ 4.8 - 2.6 = +2.2 \pm 1.4 \quad (1.6 \times 1.4 = 2.2) \end{array} \right.
 \end{array}$$

Does this increase in the tendency to intestinal disturbances depend only on the irritating influence of the drain or does the stage of the disease, for instance, together with drainage cause variations in the results? It appears in the foregoing (p. 131) that on the basis of my material it cannot be determined with certainty whether there is any relation between the stage of the disease at the time of the appendectomy and the mechanical intestinal disturbances. We shall notice from table 60 (p. 167) that *no matter at what stage of the disease the operation was performed, the duration of drainage always had the same influence. Late mechanical intestinal disturbances occur more frequently the longer the period of drainage is protracted*, which is also statistically very possible with regard to operations performed in the stages of acute appendicitis and of appendicitis with peritonitis.

Drain removed within 3 days after the operation

Diagnosis	I	.....	$1.1 - 4.6 = -3.5 \pm 2.2$	$(1.6 \times 2.2 = 3.5)$
»	II	.....	$2.4 - 4.6 = -2.2 \pm 1.9$	$(1.2 \times 1.9 = 2.3)$
»	III	.....	$2.2 - 4.6 = -2.4 \pm 1.8$	$(1.3 \times 1.8 = 2.3)$
»	II}	.....	$2.3 - 4.6 = -2.3 \pm 1.3$	$(1.8 \times 1.3 = 2.3)$
»	III}			

Drain removed later than 3 days after the operation

Diagnosis	I	.....	$8.1 - 4.6 = +3.5 \pm 2.0$	$(1.8 \times 2.0 = 3.6)$
»	II	.....	$6.3 - 4.6 = +1.7 \pm 1.4$	$(1.2 \times 1.4 = 1.8)$
»	III	.....	$5.4 - 4.6 = +0.8 \pm 1.3$	$(0.6 \times 1.3 = 0.8)$
»	II}	.....	$5.8 - 4.6 = +1.2 \pm 0.9$	$(1.3 \times 0.9 = 1.2)$
»	III}			

The circumstance that the frequency of intestinal disturbances after operations performed at the non-perforated acute stage was considerably higher than after operations in the peritonitis stage when drainage lasted for more than 3 days, may be explained by the fact that proteolytic ferment contained in the peritoneal pus has had a preventive influence upon the formation of adhesions (cf. p. 118).

Summary.

The questions which I have tried to elucidate were as follows:

1) *What is the relation of age and sex to the occurrence of incisional herniae and what is the relation between the frequencies of incisional herniae following the use of McBURNEY'S, LENNANDER'S and KROGIUS'S incision?*

2) *How does the occupation influence the occurrence of incisional herniae?*

3) *Does the circumstance on which day after the onset of the disease operation has been performed in any way influence the frequency of incisional herniae, and what is the relation of the different incisions to one another in this respect?*

4) *Does the circumstance at what stage of the disease operation is performed in any way influence the frequency of incisional herniae and are there differences in this respect which depend on the incision?*

5) *How does the duration of drainage influence the occurrence of incisional herniae?*

6) *How often were renewed operations because of incisional herniae necessary?*

7) *Do right inguinal herniae occur more frequently than usually and, in that case, how frequently, in cases operated through different appendectomy incisions?*

8) *What is the frequency in my material of mechanical intestinal disturbances following operations for appendicitis through different incisions?*

9) *Was the occurrence of postoperative mechanical intestinal disturbances in any way influenced by the fact that operation was performed at a certain stage of the disease and is there any difference in this respect between the various incisions?*

10) *Was the fact of the time at which appendectomy was performed after the onset of symptoms of any importance for the occurrence of postoperative mechanical intestinal disturbances and is there any difference in this respect between the various incisions.*

11) Did the length of the period of drainage influence the occurrence of postoperative mechanical intestinal disturbances? Is there in this respect any difference between the various incisions?

I have selected the material for my investigation from the Viipuri County Hospital (from the years 1913—1932), the Surgical Clinic of the University of Helsinki (from the years 1915—1932) and from the Maria City Hospital (from the years 1905—1932). I have used those cases of drained acute appendicitis, of appendicitis with peritonitis and of periappendicular abscess, the records of which contained all the information, besides the usual personal data, which were necessary for my investigation, viz. operative diagnosis, statement of the day on which appendectomy was performed, which incision was employed, nature of the drain as well as statement that the abdominal cavity was drained through a drain and not with the aid of a tampon, and that the laparotomy wound was closed to the drain. The reason for including also cases of acute non perforated appendicitis in my investigation is, that the exudate found in the abdominal cavity in these cases was considered due to commencing peritonitis and, being dangerous to the patient, was therefore removed as far as possible through a drain even though no other clinical symptoms of peritonitis were present. I have also limited my investigation to cases in which either McBURNEY's muscle-splitting incision, LENNANDER's or KROGIUS's pararectus incisions were employed.

My material which is based on after-inquiries and records comprises 1 062 cases of which 673 were men and 389 were women. When I collected the material the patients had been discharged from hospital at least 3 years, which is generally considered a sufficient interval for investigating the frequency of incisional herniae and purely mechanical intestinal disturbances.

The Occurrence of Incisional Herniae.

The frequency of incisional herniae in my total material was 14.1 per cent (11.0 per cent in men and 19.6 per cent in women). *With regard to the frequency of incisional herniae LENNANDER's and KROGIUS's incisions appear to be equal in value.* McBURNEY's

incision, on the other hand, is better than the former incisions, a fact also proved with statistical certainty. (For my statistical terms see p. 65).

The relation of age and sex to the occurrence of incisional herniae.

It cannot be proved with statistical certainty on the basis of my material whether the predisposition to incisional herniae depends on age except in the group of patients of 11—20 years. This group has the lowest frequency of incisional herniae in my total material, and this is also statistically proved, each incision being regarded separately.

It cannot be established at all with statistical certainty that the predisposition to incisional herniae in men should depend on age neither with regard to the total material nor each incision taken separately. The predisposition to incisional herniae in women, however, which in my material is rather high, seems to increase with age after all incisions, and this is also statistically possible. As to the frequency of incisional herniae in men and women, this frequency is almost twice as high in women (19.6 ± 1.8 per cent) as in men (11.0 ± 1.2 per cent); this also is statistically certain. When examining this relation in cases of different incisions we find that there is a small difference in the predisposition to incisional herniae between men and women in cases of MCBURNEY's incision, whereas in cases of LENNANDER's and KROGIUS's incisions there are twice as many cases of incisional herniae in women as in men, and this is also statistically certain. In the predisposition to incisional herniae (12.1 ± 2.7 per cent) in children (1—15 years) there is statistically no confirmed difference between boys and girls.

The influence of the occupation on the occurrence of incisional herniae.

When comparing the frequency of incisional herniae in labourers and intellectual workers we find that *intellectual workers have a greater predisposition to incisional herniae (18.3 per cent) than labourers (13.5 per cent).* Manual labour does therefore not increase

the predisposition to incisional herniae, but if the patient has untrained abdominal muscles, as is generally the case with intellectual workers in comparison with labourers, heavy bodily strain may give rise to an incisional hernia if other circumstances are favourable in this respect.

The relation of the interval between the onset of the disease and the operation to the occurrence of incisional herniae.

If the interval between the onset of the disease and the operation is prolonged, with a few exceptions, the predisposition to incisional herniae accordingly increases and this is also statistically established. The frequency of incisional herniae in cases operated at an early stage was 12.9 ± 1.3 per cent whereas it was 18.9 ± 1.8 per cent when the operation was performed later.

The frequency of incisional herniae following operations performed after the early stage (48 hours) increased by 1.3–4.4 per cent in the cases of different incisions; this cannot, however, be proved with statistical certainty within the limits of my material. The Mc BURNEY incision proved to be the firmest incision also in cases of later operations.

The relation of the stage of the disease to the occurrence of incisional herniae.

The stage of the disease seems to influence the occurrence of incisional herniae only provided the operation is performed *in the appendicitis acuta non-perforata stage* in which case the frequency of incisional herniae is considerably lower (6.5 ± 2.5 per cent) than after operations performed in the *peritonitis diffusa stage* (16.2 ± 1.2 per cent). This is also statistically confirmed.

The frequency of incisional herniae increases as the stage of the disease advances in cases of LENNANDER's and KROGIUS's incisions which also seems statistically possible. No definite conclusions can be drawn in this respect on the basis of my material with regard to McBURNEY's incision.

The relation of the duration of drainage to the occurrence of incisional herniae.

The predisposition to incisional herniae seems also to increase if the period of drainage is prolonged, no matter in which stage of the disease the operation is performed, and this is also statistically possible. When the drain was removed within 3 days the frequency of incisional herniae was 11.2 ± 1.8 per cent whereas it was 15.6 ± 1.3 per cent after drainage of longer duration.

In cases of MCBURNEY's and LENNANDER's incisions it is also statistically possible that the frequency of incisional herniae increases as drainage is prolonged, whereas this is almost certain in cases of KROGIUS's incision. When comparing the firmness of the abdominal wall in cases of different incisions we find that if drainage lasts longer than 3 days the predisposition to incisional herniae in cases of MCBURNEY's incision is less by half than in cases of LENNANDER's and less by one third than in cases of KROGIUS's incision.

Renewed operations caused by incisional herniae.

Renewed operations because of incisional herniae following MCBURNEY's incision occurred with a frequency of one half less than after LENNANDER's and KROGIUS's incisions, and only in cases of strangulation. However, strangulation of incisional herniae following MCBURNEY's incision was more common than in cases of LENNANDER's and KROGIUS's incisions.

The frequency of the original appendectomies which lead to renewed operations was one fourth less in cases of MCBURNEY's incision than in cases of LENNANDER's and KROGIUS's incisions.

The occurrence of inguinal herniae after various appendectomy incisions.

According to LEHMANN the frequency of inguinal herniae is 2.1 — 2.8 per cent while the frequency of inguinal herniae following operations in my material is 2.4 ± 0.4 per cent; the inguinal herniae in my material might therefore have become manifest also without

appendectomy. I cannot therefore state that appendectomy with all the various factors connected with it, has been a decisive factor in the occurrence of these hernia. If we investigate this question, however in connection with operations performed at the peritonitis diffusa universalis stage, we shall find that right inguinal herniae occur in 5.9 ± 1.4 per cent of the cases of MCBURNEY's incision and in 5.1 ± 1.3 per cent of the cases of LENNANDER's incision, which correlation values can also be statistically proved to belong to that class of diagnoses. Therefore, if the peritonitis is far advanced and the incision as well as the period of drainage is long, the operation may be followed by a considerable number of right inguinal herniae in persons who have a congenital predisposition to herniation.

The reasons for the occurrence of inguinal herniae according to literature are: when MCBURNEY's incision is employed, injury to the ilio-inguinal and the iliohypogastric nerve, and in cases of LENNANDER's incision functional disturbances in the abdominal wall. In both these incisions general weakness and injury of the abdominal layers owing to peritonitis are also of importance, KROGIUS's incision does not seem to influence the manifestation of inguinal herniae.

Thus, if we compare the three appendectomy incisions in question to one another as the causes of right inguinal herniae we shall find, on the basis of my material, that MCBURNEY's incision seems to cause inguinal herniae more frequently than LENNANDER's and KROGIUS's incisions.

The occurrence mechanical intestinal disturbances.

49 (4.6 ± 0.7 per cent) patients out of 1 062 after-examined patients suffered from symptoms of either partial or complete intestinal obstruction or pains of suspected adhesions. Total occlusion occurred in 7 patients (0.7 ± 0.3 per cent) being distributed in relation to the various incisions as follows: in cases of MCBURNEY's incision the frequency of mechanical intestinal disturbances was 4.0 ± 1.0 per cent, in cases of LENNANDER's incision 6.7 ± 1.3 per cent, and in cases of KROGIUS's incisions 2.6 ± 0.9 per cent.

The influence of the stage of the disease.

Mechanical intestinal disturbances do not seem to be influenced to any noticeable extent by the stage of the disease at which operation was performed, nor can any such influence be noticed when the different incisions are investigated separately in this respect. If, however, only total occlusions are considered we find that the frequency of such occlusions is highest after operations at the abscess stage, a fact also confirmed by literature.

The influence by the duration of the disease.

According to my material, the day of the disease on which operation is performed, is of no great importance for the occurrence of mechanical intestinal disturbances. If the frequency of complete occlusion is examined separately we shall find that it is more than four times higher (0.3 ± 0.3 per cent $\rightarrow 1.3 \pm 0.4$ per cent) if the operation is performed after the early stage i.e. (operations performed within 48 hours) which is also statistically possible.

The influence of the duration of drainage.

The majority of the cases of mechanical intestinal disturbances (89 per cent) occurred in cases in which drainage lasted longer than 3 days. When drainage lasted 3 days at the most, the frequency of mechanical intestinal disturbances was 1.9 ± 1.1 per cent, and in cases with prolonged drainage 6.0 ± 0.8 per cent, thus three times as high. It can also be statistically established that with a prolonged drainage the tendency to mechanical intestinal disturbances increases. When drainage did not last more than three days, complete occlusions did not occur at all.

As a further example of the irritating influence of the drain it should be mentioned that after the operations of my total material, stercoral fistulae occurred in 6 cases (0.6 ± 0.2 per cent) all following operations at the peritonitis diffusa stage. In 5 cases out of these the drainage lasted more than 5 days and only in one case 3 days.

With regard to all the different incisions the frequency of mechanical intestinal disturbances in my material has increased as the period of drainage has been prolonged. — It appears further from my cases that at whatever stage of the disease operation was performed, prolonged drainage had always the same negative influence: the longer the period of drainage lasted the more mechanical intestinal disturbances occurred later.

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¹ Abbreviations according to the World List of Scientific Periodicals.

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TABLE 33. The relation of the duration of drainage to the occurrence of incisional herniae in cases operated at different stages of the disease.

Maximum lapse of time between operation and removal of drain	I. Appendicitis acuta non perforata				II. Appendicitis acuta perforata et peritonitis diffusa incipiens				III. Appendicitis acuta perforata et peritonitis diffusa universalis				II + III. Appendicitis acuta perforata et peritonitis diffusa incipiens et universalis				Abscessus periappendicularis				Total			
	Number of operations	Number of incisional herniae	Percentage of incisional herniae	Percentage of mean error ϵ (p)	Number of operations	Number of incisional herniae	Percentage of incisional herniae	Percentage of mean error ϵ (p)	Number of operations	Number of incisional herniae	Percentage of incisional herniae	Percentage of mean error ϵ (p)	Number of operations	Number of incisional herniae	Percentage of incisional herniae	Percentage of mean error ϵ (p)	Number of operations	Number of incisional herniae	Percentage of incisional herniae	Percentage of mean error ϵ (p)	Number of operations	Number of incisional herniae	Percentage of incisional herniae	Percentage of mean error ϵ (p)
24 hours	14	1	7.1	± 3.7	16	3	18.8	± 3.1	14	6	43	± 3.0	61	9	15.0	± 2.2	1	—	—	—	75	10	11.2	± 1.8
48 "	33	1	3.0		50	8	16.0		19	8	42.1		99	16	16.2		9	—	—		141	17		
72 "	41	—	—		60	6	10.0		11	8	72.7		101	14	13.9		7	—	—		119	14		
5 days	45	3	6.7	± 3.3	73	13	17.8	± 2.2	71	10	14.1	± 2.1	144	23	15.3	± 1.5	18	1	5.6	4.5	207	27	13.6	± 1.3
7 " or more	66	8	12.1		167	26	15.6		209	38	18.2		376	61	17.0		18	10	20.8		490	82		
Total	199	13	6.5	± 1.7	366	56	15.3	± 1.9	411	70	16.9	± 1.9	780	126	16.0	± 1.3	83	11	13.3	± 3.8	1 062	150	14.1	± 1.1

TABLE 60. The relation of the duration of drainage to the frequency of mechanical intestinal disturbances in cases operated at different stages of the disease.

Maximum lapse of time between operation and removal of drain	I. Appendicitis acuta non perforata				II. Appendicitis acuta perforata et peritonitis diffusa incipiens				III. Appendicitis acuta perforata et peritonitis diffusa universalis				II + III. Appendicitis acuta perforata et peritonitis diffusa incipiens et universalis				IV. Abscessus periappendicularis				Total			
	Number of operations	Number of cases of intestinal disturbances	Percentage of intestinal disturbances	Percentage of mean error ϵ (p)	Number of operations	Number of cases of intestinal disturbances	Percentage of intestinal disturbances	Percentage of mean error ϵ (p)	Number of operations	Number of cases of intestinal disturbances	Percentage of intestinal disturbances	Percentage of mean error ϵ (p)	Number of operations	Number of cases of intestinal disturbances	Percentage of intestinal disturbances	Percentage of mean error ϵ (p)	Number of operations	Number of cases of intestinal disturbances	Percentage of intestinal disturbances	Percentage of mean error ϵ (p)	Number of operations	Number of cases of intestinal disturbances	Percentage of intestinal disturbances	Percentage of mean error ϵ (p)
24 hours	14	—	1.1	± 2.2	16	—	2.4	± 1.9	44	1	2.2	± 1.8	60	1	1.7	± 1.3	1	—	—	—	75	1	1.9	± 1.1
48 "	33	—			50	2			41	2			99	1	1.0		9	—	—		111	1		
72 "	41	1			60	2			11	2			101	4	4.0		7	—	—		149	5		
5 days	45	4	8.1	± 2.0	73	7	6.3	± 1.4	71	6	5.4	± 1.3	144	13	9.0	± 0.9	18	2	4.5	± 2.5	207	19	6.2	± 0.8
7 " or more	66	5			167	8			209	9			376	17	4.5		48	1	—		490	23		
Total	199	10	5.0	± 1.5	366	18	4.9	± 1.1	411	18	4.6	± 1.1	780	36	4.6	± 0.7	83	3	3.6	± 2.3	1 062	49	4.6	± 0.7



